Exhibit 4

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Monsees et al.

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(54) **CARTRIDGE FOR USE WITH A VAPORIZER DEVICE**

(71) Applicant: **JUUL Labs, Inc.**, San Francisco, CA (US)

(72) Inventors: **James Monsees**, San Francisco, CA (US); **Adam Bowen**, San Francisco, CA (US); **Steven Christensen**, San Francisco, CA (US); **Joshua Morenstein**, San Francisco, CA (US); **Christopher Nicholas HibmaCronan**, Oakland, CA (US)

(73) Assignee: **JUUL Labs, Inc.**, San Francisco, CA (US)

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(58) **Field of Classification Search**
None
See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

374,584 A 12/1887 Cook
576,653 A 2/1897 Bowlby
(Continued)

FOREIGN PATENT DOCUMENTS

AU 2014206215 A1 8/2014
AU 2014208287 A1 8/2014
(Continued)

OTHER PUBLICATIONS

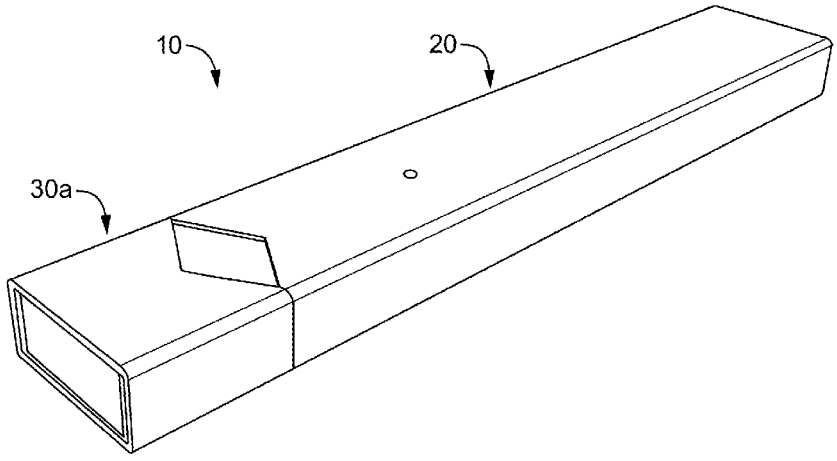
"Commission Regulation (EC) No. 1275/2008," Official Journal of the European Union, Dec. 17, 2008.
(Continued)

Primary Examiner — Michael J Felton
(74) *Attorney, Agent, or Firm* — Mintz, Levin, Cohn, Ferris, Glovsky and Popeo, P.C.

(57) **ABSTRACT**

Cartridges for generating an aerosol are provided. In some implementations, a cartridge comprises a body, a heating element, and a mouthpiece. The body includes a storage compartment configured to hold a vaporizable material and has a first end, a second end, and a surface between the first end and the second end. The mouthpiece is secured over the first end, has a notch extending away from the second end towards the first end, covers a first portion of the surface, does not cover a second portion of the surface configured for insertion into a cartridge receptacle of a vaporizer device, and does not cover a third portion of the surface comprising an area between the notch and the second end, the third portion of the surface being visible when the second portion of the surface is inserted into the cartridge receptacle.

21 Claims, 24 Drawing Sheets



Related U.S. Application Data

application No. 14/581,666, filed on Dec. 23, 2014, which is a continuation-in-part of application No. 35/001,169, filed on Jul. 28, 2016 (U.S. filing date under 35 U.S.C. 384), and having an international filing date of Mar. 11, 2016, which is a continuation-in-part of application No. 35/001,170, filed on Jul. 28, 2016 (U.S. filing date under 35 U.S.C. 384), and having an international filing date of Mar. 11, 2016.

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(56) **References Cited**

U.S. PATENT DOCUMENTS

595,070	A	12/1897	Oldenbusch
720,007	A	2/1903	Dexter
799,844	A	9/1905	Fuller
968,160	A	8/1910	Johnson
969,076	A	8/1910	Pender
1,067,531	A	7/1913	MacGregor
1,163,183	A	12/1915	Stoll
1,299,162	A	4/1919	Fisher
1,505,748	A	8/1924	Louis
1,552,877	A	9/1925	Phillipps et al.
1,632,335	A	6/1927	Hiering
1,706,244	A	3/1929	Louis
1,845,340	A	2/1932	Ritz
1,972,118	A	9/1934	McDill
1,998,683	A	4/1935	Montgomery
2,031,363	A	2/1936	Elof
2,039,559	A	5/1936	Segal
2,104,266	A	1/1938	McCormick
2,159,698	A	5/1939	Harris et al.
2,177,636	A	10/1939	Coffelt et al.
2,195,260	A	3/1940	Rasener
2,231,909	A	2/1941	Hempal
2,327,120	A	8/1943	McCoon
D142,178	S	8/1945	Becwar
2,460,427	A	2/1949	Musselman et al.
2,483,304	A	9/1949	Rudolf
2,502,561	A	4/1950	Ludwig
2,765,949	A	10/1956	Swan
2,830,597	A	4/1958	Kummli
2,860,638	A	11/1958	Bartolomeo
2,897,958	A	8/1959	Tarleton et al.
2,935,987	A	5/1960	Ackerbauer
3,085,145	A	4/1963	Wray
3,146,937	A	9/1964	Joseph
3,258,015	A	6/1966	Ellis et al.
3,271,719	A	9/1966	Ovshinsky
3,292,634	A	12/1966	Beucler
D207,887	S	6/1967	Parsisson
3,373,915	A	3/1968	Anderson et al.
3,420,360	A	1/1969	Young
3,443,827	A	5/1969	Acker et al.
3,456,645	A	7/1969	Brock
3,479,561	A	11/1969	Janning
3,567,014	A	3/1971	Feigelman
3,675,661	A	7/1972	Weaver
3,707,017	A	12/1972	Paquette
3,792,704	A	2/1974	Parker
3,815,597	A	6/1974	Goettelman
3,861,523	A	1/1975	Fountain et al.
3,941,300	A	3/1976	Troth
4,020,853	A	5/1977	Nuttall
4,049,005	A	9/1977	Hernandez et al.
4,066,088	A	1/1978	Ensor
D250,485	S	12/1978	Cuthbertson
D255,548	S	6/1980	Grodin
4,207,976	A	6/1980	Herman
4,215,708	A	8/1980	Bron
4,219,032	A	8/1980	Tabatznik et al.
D260,690	S	9/1981	Stutzer
4,303,083	A	12/1981	Burruss, Jr.
4,312,367	A	1/1982	Seeman
4,347,855	A	9/1982	Lanzillotti et al.
4,391,285	A	7/1983	Burnett et al.
D271,255	S	11/1983	Rousseau
4,492,480	A	1/1985	Wadso et al.
4,506,683	A	3/1985	Cantrell et al.
4,519,319	A	5/1985	Howlett
4,520,938	A	6/1985	Finke
D280,494	S	9/1985	Abel
4,595,024	A	6/1986	Greene et al.
4,625,737	A	12/1986	Keritsis et al.
4,648,393	A	3/1987	Landis et al.
4,708,151	A	11/1987	Shelar
4,735,217	A	4/1988	Gerth et al.
4,771,796	A	9/1988	Myer
4,793,365	A	12/1988	Sensabaugh, Jr. et al.
4,794,323	A	12/1988	Zhou et al.
4,798,310	A	1/1989	Kasai et al.
4,813,536	A	3/1989	Willis
4,819,665	A	4/1989	Roberts et al.
4,830,028	A	5/1989	Lawson et al.
D301,837	S	6/1989	Peterson et al.
4,836,224	A	6/1989	Lawson et al.
4,846,199	A	7/1989	Rose
4,848,374	A	7/1989	Chard et al.
4,848,563	A	7/1989	Robbins
D302,659	S	8/1989	Peterson et al.
D303,722	S	9/1989	Marlow et al.
4,870,748	A	10/1989	Hensgen et al.
D304,771	S	11/1989	Katayama
4,893,639	A	1/1990	White
4,896,683	A	1/1990	Cohen et al.
4,907,606	A	3/1990	Lilja et al.
4,924,883	A	5/1990	Perfetti et al.
4,938,236	A	7/1990	Banerjee et al.
4,941,483	A	7/1990	Ridings et al.
4,944,317	A	7/1990	Thal
D310,171	S	8/1990	Cusenza
4,945,929	A	8/1990	Egilmex
4,947,874	A	8/1990	Brooks et al.
4,947,875	A	8/1990	Brooks et al.
D310,349	S	9/1990	Rowen
4,955,397	A	9/1990	Johnson et al.
4,974,609	A	12/1990	Southwick et al.
4,984,588	A	1/1991	Stewart, Jr.
D315,032	S	2/1991	Hayes
5,005,759	A	4/1991	Bouche
5,019,122	A	5/1991	Clearman et al.
5,020,548	A	6/1991	Farrier et al.
5,027,836	A	7/1991	Shannon et al.
5,031,646	A	7/1991	Lippiello et al.
5,040,551	A	8/1991	Schlatter et al.
5,042,509	A	8/1991	Banerjee et al.
5,050,621	A	9/1991	Creighton et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,060,671 A 10/1991 Counts et al.
5,065,776 A 11/1991 Lawson et al.
5,076,297 A 12/1991 Farrier et al.
5,101,838 A 4/1992 Schwartz et al.
5,105,831 A 4/1992 Banerjee et al.
5,105,836 A 4/1992 Gentry et al.
5,105,838 A 4/1992 White et al.
5,123,530 A 6/1992 Lee
5,127,511 A 7/1992 Keen, Jr. et al.
5,133,368 A 7/1992 Neumann et al.
5,141,004 A 8/1992 Porenski
5,144,962 A 9/1992 Counts et al.
5,148,817 A 9/1992 Houminer et al.
5,152,456 A 10/1992 Ross et al.
5,183,062 A 2/1993 Clearman et al.
D336,346 S 6/1993 Miller et al.
5,224,498 A 7/1993 Deevi et al.
5,228,460 A 7/1993 Sprinkel et al.
5,240,012 A 8/1993 Ehrman et al.
5,249,586 A 10/1993 Morgan et al.
5,261,424 A 11/1993 Sprinkel, Jr.
5,269,237 A 12/1993 Baker et al.
5,269,327 A 12/1993 Counts et al.
5,296,685 A 3/1994 Burstein et al.
5,303,720 A 4/1994 Banerjee et al.
5,322,075 A 6/1994 Deevi et al.
5,324,498 A 6/1994 Streusand et al.
5,345,951 A 9/1994 Serrano et al.
5,369,723 A 11/1994 Counts et al.
5,372,148 A 12/1994 McCafferty et al.
5,388,574 A 2/1995 Ingebrethsen
5,449,078 A 9/1995 Akers
5,456,269 A 10/1995 Kollasch
5,472,001 A 12/1995 Nicholson
D367,605 S 3/1996 Moore
5,497,791 A 3/1996 Bowen et al.
D368,552 S 4/1996 Adams
5,529,078 A 6/1996 Rehder et al.
D371,633 S 7/1996 Chenard
5,545,904 A 8/1996 Orbach
5,564,442 A 10/1996 MacDonald et al.
5,579,934 A 12/1996 Buono
5,591,368 A 1/1997 Fleischhauer et al.
5,605,226 A 2/1997 Hernlein
D379,810 S 6/1997 Giordano, Jr. et al.
5,641,064 A 6/1997 Goserud
D380,293 S 7/1997 Cudmore
5,649,552 A 7/1997 Cho et al.
D382,146 S 8/1997 Sandy
5,666,977 A 9/1997 Higgins et al.
5,666,978 A 9/1997 Counts et al.
5,708,258 A 1/1998 Counts et al.
5,730,118 A 3/1998 Hermanson
5,730,158 A 3/1998 Collins et al.
5,746,587 A 5/1998 Racine et al.
D397,504 S 8/1998 Zelenik
D398,150 S 9/1998 Vonarburg
5,810,164 A 9/1998 Rennecamp
5,819,756 A 10/1998 Mielordt
5,845,649 A 12/1998 Saito et al.
D405,007 S 2/1999 Naas, Sr.
5,865,185 A 2/1999 Collins et al.
5,865,186 A 2/1999 Volsey, II
5,878,752 A 3/1999 Adams et al.
5,881,884 A 3/1999 Podosek
5,894,841 A 4/1999 Voges
D411,332 S 6/1999 Zelenik
D412,279 S 7/1999 Brice
5,931,828 A 8/1999 Durkee
5,934,289 A 8/1999 Watkins et al.
5,938,018 A 8/1999 Keaveney et al.
5,944,025 A 8/1999 Cook et al.
5,954,979 A 9/1999 Counts et al.
D414,893 S 10/1999 Moore
5,967,310 A 10/1999 Hill
5,975,415 A 11/1999 Zehnal
5,979,460 A 11/1999 Matsumura
5,994,025 A 11/1999 Iwasa et al.
5,996,589 A 12/1999 St. Charles
6,024,097 A 2/2000 Von Wielligh
6,026,820 A 2/2000 Baggett, Jr. et al.
6,040,560 A 3/2000 Fleischhauer et al.
D422,884 S 4/2000 Lafond
6,053,176 A 4/2000 Adams et al.
D424,236 S 5/2000 Reed
6,089,857 A 7/2000 Matsuura et al.
6,095,153 A 8/2000 Kessler et al.
6,102,036 A 8/2000 Slutsky et al.
6,119,684 A 9/2000 Nohl et al.
6,125,853 A 10/2000 Susa et al.
D433,532 S 11/2000 Higgins et al.
6,155,268 A 12/2000 Takeuchi
6,164,287 A 12/2000 White
D436,686 S 1/2001 Fujisawa
6,196,232 B1 3/2001 Chkadua
6,216,705 B1 4/2001 Ossepian
D442,328 S 5/2001 Barmes
6,234,169 B1 5/2001 Bulbrook et al.
6,265,789 B1 7/2001 Honda et al.
D447,276 S 8/2001 Gustafson
6,269,966 B1 8/2001 Pallo et al.
D450,313 S 11/2001 Koinuma
D450,662 S 11/2001 Kwok
6,324,261 B1 11/2001 Merte
6,349,728 B1 2/2002 Pham
D454,079 S 3/2002 Fong
6,381,739 B1 4/2002 Breternitz, Jr. et al.
6,386,371 B1 5/2002 Parsons
6,407,371 B1 6/2002 Toya et al.
6,418,938 B1 7/2002 Fleischhauer et al.
6,431,363 B1 8/2002 Hacker
6,443,146 B1 9/2002 Voges
6,446,793 B1 9/2002 Layshock
D465,660 S 11/2002 Doeing
6,510,982 B2 1/2003 White et al.
D471,104 S 3/2003 Hunt
6,532,965 B1 3/2003 Abhulimen et al.
6,536,442 B2 3/2003 St Charles et al.
6,557,708 B2 5/2003 Polacco
6,598,607 B2 7/2003 Adiga et al.
D477,920 S 8/2003 McCarty et al.
D478,569 S 8/2003 Hussaini et al.
D478,897 S 8/2003 Tsuge
6,603,924 B2 8/2003 Brown et al.
6,606,998 B1 8/2003 Gold
6,612,404 B2 9/2003 Sweet et al.
6,615,840 B1 9/2003 Fournier et al.
6,622,867 B2 9/2003 Menceles
6,637,430 B1 10/2003 Voges et al.
6,655,379 B2 12/2003 Clark et al.
D485,639 S 1/2004 Stronski
6,672,762 B1 1/2004 Faircloth et al.
6,688,313 B2 2/2004 Wrenn et al.
6,707,274 B1 3/2004 Karr
6,708,846 B1 3/2004 Fuchs et al.
6,726,006 B1 4/2004 Funderburk et al.
6,743,030 B2 6/2004 Lin et al.
6,747,573 B1 6/2004 Gerlach et al.
6,752,649 B2 6/2004 Arkin et al.
D494,315 S 8/2004 Cartier
6,769,436 B2 8/2004 Horian
6,772,756 B2 8/2004 Shayan
D495,599 S 9/2004 Biesecker
6,799,576 B2 10/2004 Farr
6,803,545 B2 10/2004 Blake et al.
6,803,744 B1 10/2004 Sabo
6,805,545 B2 10/2004 Slaboden
6,810,883 B2 11/2004 Felter et al.
D500,301 S 12/2004 Deguchi
D500,302 S 12/2004 Deguchi
6,827,573 B2 12/2004 St. Charles et al.
6,854,470 B1 2/2005 Pu
6,874,507 B2 4/2005 Farr
D505,922 S 6/2005 Mayo et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D506,447 S 6/2005 Mayo et al.
D506,731 S 6/2005 Mayo et al.
6,909,840 B2 6/2005 Harwig et al.
D507,244 S 7/2005 Mayo et al.
6,923,890 B2 8/2005 Ricatto et al.
6,954,979 B2 10/2005 Logan
6,994,096 B2 2/2006 Rostami et al.
7,000,775 B2 2/2006 Gelardi et al.
7,015,796 B2 3/2006 Snyder
7,025,066 B2 4/2006 Lawson et al.
D523,171 S 6/2006 Mitten et al.
D525,948 S 8/2006 Blair et al.
7,082,825 B2 8/2006 Aoshima et al.
D528,992 S 9/2006 Hobart et al.
D529,044 S 9/2006 Andre et al.
7,109,876 B2 9/2006 Smith et al.
D530,340 S 10/2006 Andre et al.
D531,190 S 10/2006 Lee et al.
7,117,707 B2 10/2006 Adams et al.
D532,927 S 11/2006 Sann
D534,921 S 1/2007 Andre et al.
D535,261 S 1/2007 Daniels
D535,308 S 1/2007 Andre et al.
7,173,222 B2 2/2007 Cox et al.
7,185,659 B2 3/2007 Sharpe
D539,813 S 4/2007 Chen
D540,687 S 4/2007 Egawa
D540,749 S 4/2007 Kaule
7,214,075 B2 5/2007 He et al.
D544,643 S 6/2007 Lin
D545,303 S 6/2007 Chang
7,234,593 B2 6/2007 Fath et al.
D545,904 S 7/2007 Chen et al.
D546,782 S 7/2007 Poulet et al.
D547,002 S 7/2007 Lin
D551,548 S 9/2007 Didier
D551,970 S 10/2007 Didier
7,275,941 B1 10/2007 Bushby
D556,154 S 11/2007 Poulet et al.
7,290,549 B2 11/2007 Banerjee et al.
D557,209 S 12/2007 Ahlgren et al.
D558,060 S 12/2007 Milan Sir
D562,151 S 2/2008 Larocca et al.
D565,496 S 4/2008 Disla
D568,298 S 5/2008 Lundgren et al.
D569,727 S 5/2008 Moretti
7,374,048 B2 5/2008 Mazurek
D571,202 S 6/2008 Vogt
D571,556 S 6/2008 Raile
D573,474 S 7/2008 Beam et al.
7,415,982 B1 8/2008 Sheridan
D576,619 S 9/2008 Udagawa et al.
D577,019 S 9/2008 Udagawa et al.
D577,150 S 9/2008 Bryman et al.
D577,591 S 9/2008 Bouroullec et al.
7,428,905 B2 9/2008 Mua
7,434,584 B2 10/2008 Steinberg
D580,756 S 11/2008 Seebold
D585,077 S 1/2009 Sheba et al.
7,488,171 B2 2/2009 St. Charles et al.
D589,941 S 4/2009 Maier et al.
D590,988 S 4/2009 Hon
D590,989 S 4/2009 Hon
D590,990 S 4/2009 Hon
D590,991 S 4/2009 Hon
D591,758 S 5/2009 Lee
7,530,352 B2 5/2009 Childers et al.
7,546,703 B2 6/2009 Johnske et al.
D599,670 S 9/2009 Qin
7,581,540 B2 9/2009 Hale et al.
7,621,403 B2 11/2009 Althoff et al.
D605,509 S 12/2009 Leonardis
D606,505 S 12/2009 Seflic et al.
7,633,270 B2 12/2009 Wong et al.
7,644,823 B2 1/2010 Gelardi et al.
D610,588 S 2/2010 Chen
D611,409 S 3/2010 Green et al.
D616,753 S 6/2010 Beam et al.
7,726,320 B2 6/2010 Robinson et al.
7,753,055 B2 7/2010 Bryman
D621,357 S 8/2010 Dong
7,767,698 B2 8/2010 Warchol et al.
D624,238 S 9/2010 Turner
7,793,860 B2 9/2010 Bankers et al.
7,793,861 B2 9/2010 Bankers et al.
7,801,573 B2 9/2010 Yazdi et al.
D624,880 S 10/2010 Felegy, Jr. et al.
7,813,832 B2 10/2010 Sundar
7,815,332 B1 10/2010 Smith
D627,962 S 11/2010 Mudrick
7,832,397 B2 11/2010 Lipowicz
7,832,410 B2 11/2010 Hon
7,845,359 B2 12/2010 Montaser
D631,055 S 1/2011 Gilbert et al.
D631,458 S 1/2011 Liao et al.
7,886,507 B2 2/2011 McGuinness, Jr.
7,891,666 B2 2/2011 Kuenzler et al.
D634,735 S 3/2011 Maier
7,905,236 B2 3/2011 Bryman et al.
7,913,686 B2 3/2011 Hughes et al.
D639,303 S 6/2011 Ni et al.
D639,782 S 6/2011 Kim
D641,718 S 7/2011 Sakai
D642,330 S 7/2011 Turner
D644,375 S 8/2011 Zhou
7,987,846 B2 8/2011 Hale et al.
7,988,034 B2 8/2011 Pezzoli
8,003,080 B2 8/2011 Rabinowitz et al.
D645,817 S 9/2011 Sasada et al.
D647,247 S 10/2011 Jones
8,042,550 B2 10/2011 Urtsev et al.
D649,708 S 11/2011 Oneil
D649,932 S 12/2011 Symons
8,079,371 B2 12/2011 Robinson et al.
8,080,975 B2 12/2011 Bessa et al.
8,091,558 B2 1/2012 Martzel
D653,803 S 2/2012 Timmermans
D656,496 S 3/2012 Andre et al.
8,141,701 B2 3/2012 Hodges
8,156,944 B2 4/2012 Han
8,157,918 B2 4/2012 Becker et al.
8,170,623 B2 5/2012 Dorogusker et al.
D661,889 S 6/2012 Wu
D661,991 S 6/2012 Brummelhuis et al.
8,205,622 B2 6/2012 Pan
D664,146 S 7/2012 Hoehn et al.
D664,636 S 7/2012 Robinson et al.
8,251,060 B2 8/2012 White et al.
8,282,995 B2 10/2012 Calzia et al.
D670,272 S 11/2012 Suzuki
D670,659 S 11/2012 Ishikawa et al.
8,308,624 B2 11/2012 Travers et al.
8,314,235 B2 11/2012 Dixit et al.
D672,715 S 12/2012 Brunner et al.
8,322,350 B2 12/2012 Lipowicz
D674,182 S 1/2013 Copeland et al.
D674,748 S 1/2013 Ferber et al.
8,344,693 B2 1/2013 Budziszek et al.
D676,741 S 2/2013 Van Landsveld et al.
8,371,310 B2 2/2013 Brenneise
8,375,957 B2 2/2013 Hon
8,381,739 B2 2/2013 Gonda
8,387,612 B2 3/2013 Damani et al.
8,393,331 B2 3/2013 Hon
8,402,978 B2 3/2013 Karles et al.
8,424,539 B2 4/2013 Braunshteyn et al.
D681,445 S 5/2013 Van Landsveld et al.
D682,090 S 5/2013 Scatterday
D682,698 S 5/2013 Young
D682,841 S 5/2013 Suetake et al.
8,443,534 B2 5/2013 Goodfellow et al.
D684,683 S 6/2013 Curti et al.
8,464,867 B2 6/2013 Holloway et al.
D686,336 S 7/2013 Horian

(56) **References Cited**

U.S. PATENT DOCUMENTS

D686,987	S	7/2013	Vanstone et al.
D687,042	S	7/2013	Yoneta et al.
8,479,747	B2	7/2013	O'Connell
8,490,629	B1	7/2013	Shenassa et al.
8,495,998	B2	7/2013	Schennum
8,499,766	B1	8/2013	Newton
8,511,318	B2	8/2013	Hon
D690,461	S	9/2013	Chen
8,539,959	B1	9/2013	Scatterday
8,541,401	B2	9/2013	Mishra et al.
D691,324	S	10/2013	Saliman
D692,615	S	10/2013	Verleur
8,550,069	B2	10/2013	Alelov
8,552,691	B2	10/2013	Wu
D693,054	S	11/2013	Verleur
8,578,942	B2	11/2013	Schennum
8,578,943	B2	11/2013	Luan et al.
D695,450	S	12/2013	Benassayag et al.
D696,051	S	12/2013	Scatterday
8,596,460	B2	12/2013	Scatterday
8,646,462	B2	2/2014	Yamada et al.
D700,572	S	3/2014	Esses
8,671,952	B2	3/2014	Winterson et al.
8,678,012	B2	3/2014	Li et al.
8,689,789	B2	4/2014	Andrus et al.
8,689,805	B2	4/2014	Hon
8,695,794	B2	4/2014	Scatterday
8,707,965	B2	4/2014	Newton
D704,629	S	5/2014	Liu
D704,634	S	5/2014	Eidelman et al.
D705,918	S	5/2014	Robinson et al.
8,714,150	B2	5/2014	Alelov
8,714,161	B2	5/2014	Liu
8,733,345	B2	5/2014	Siller
8,733,346	B2	5/2014	Rinker
D707,389	S	6/2014	Liu
D707,627	S	6/2014	Brunner et al.
8,739,788	B2	6/2014	Yomtov
8,741,348	B2	6/2014	Hansson et al.
8,752,545	B2	6/2014	Buchberger
8,752,557	B2	6/2014	Lipowicz
8,757,169	B2	6/2014	Gysland
D708,727	S	7/2014	Postma
8,770,187	B2	7/2014	Murphy
8,781,307	B2	7/2014	Buzzetti
8,790,556	B2	7/2014	Bundren et al.
8,794,231	B2	8/2014	Thorens et al.
8,794,244	B2	8/2014	Hammel et al.
8,794,245	B1	8/2014	Scatterday
8,794,434	B2	8/2014	Scatterday et al.
8,807,140	B1	8/2014	Scatterday
8,809,261	B2	8/2014	Elsohly et al.
8,813,747	B2	8/2014	Gibson et al.
8,813,759	B1	8/2014	Horian
8,820,330	B2	9/2014	Bellinger et al.
8,829,395	B2	9/2014	Bao
8,851,068	B2	10/2014	Cohen et al.
8,851,081	B2	10/2014	Fernando et al.
8,851,083	B2	10/2014	Oglesby et al.
8,857,446	B2	10/2014	Wu
8,863,752	B2	10/2014	Hon
8,869,792	B1	10/2014	Lee
8,881,737	B2	11/2014	Collett et al.
8,881,738	B2	11/2014	Bryman
8,893,726	B2	11/2014	Hon
8,897,628	B2	11/2014	Conley et al.
D718,621	S	12/2014	Mitchell et al.
D718,723	S	12/2014	Clymer et al.
D718,933	S	12/2014	Brown, Jr.
D719,701	S	12/2014	Scatterday
D720,095	S	12/2014	Alima
D720,496	S	12/2014	Alima
D720,497	S	12/2014	Alima
8,899,238	B2	12/2014	Robinson et al.
8,899,240	B2	12/2014	Mass
8,905,040	B2	12/2014	Scatterday et al.
8,910,630	B2	12/2014	Todd
8,910,639	B2	12/2014	Chang et al.
8,910,640	B2	12/2014	Sears et al.
8,910,641	B2	12/2014	Hon
8,910,783	B2	12/2014	Liu
8,915,254	B2	12/2014	Monsees et al.
8,919,561	B2	12/2014	Boisseau
D721,202	S	1/2015	Liu
D721,577	S	1/2015	Scatterday
8,925,555	B2	1/2015	Monsees et al.
8,928,277	B2	1/2015	Xiang et al.
8,931,492	B2	1/2015	Scatterday
D721,972	S	2/2015	Brewer et al.
D722,023	S	2/2015	Brunner et al.
8,948,578	B2	2/2015	Buchberger
8,950,395	B2	2/2015	Schennum
8,955,522	B1	2/2015	Bowen et al.
8,960,199	B2	2/2015	Zhuang et al.
8,961,492	B2	2/2015	Imran et al.
8,963,725	B2	2/2015	Xiang
D723,735	S	3/2015	Liu
D723,736	S	3/2015	Liu
D724,037	S	3/2015	Yoshioka
D725,310	S	3/2015	Eksouzian
D725,823	S	3/2015	Scatterday et al.
8,967,382	B2	3/2015	Liu
8,973,587	B2	3/2015	Liu
8,975,764	B1	3/2015	Abehasera
8,978,663	B2	3/2015	Newton
8,991,402	B2	3/2015	Bowen et al.
8,993,836	B2	3/2015	Tissier et al.
D726,727	S	4/2015	Holz et al.
9,004,073	B2	4/2015	Tucker et al.
9,010,335	B1	4/2015	Scatterday
9,016,274	B1	4/2015	White
9,018,899	B2	4/2015	Xiang
D728,855	S	5/2015	Liu
D729,030	S	5/2015	Novick et al.
D729,277	S	5/2015	Uchida
D729,366	S	5/2015	Kauss et al.
D729,439	S	5/2015	Scatterday
D729,444	S	5/2015	Leidel
D729,445	S	5/2015	Leidel
D730,571	S	5/2015	Chen
D730,572	S	5/2015	Leidel
9,022,026	B2	5/2015	Fang
9,022,039	B2	5/2015	Hearn
9,025,291	B2	5/2015	Xiang
9,028,808	B2	5/2015	Huland
9,032,968	B2	5/2015	Glasberg et al.
9,038,626	B2	5/2015	Yamada et al.
9,038,642	B2	5/2015	Liu
D731,114	S	6/2015	Leidel
D733,142	S	6/2015	Solomon et al.
D733,356	S	6/2015	Leidel
9,046,278	B2	6/2015	Koller
9,050,431	B2	6/2015	Turner et al.
9,055,617	B2	6/2015	Thorens et al.
9,055,770	B2	6/2015	Liu
9,060,388	B2	6/2015	Liu
9,060,548	B2	6/2015	Zheng et al.
9,066,543	B2	6/2015	Cameron
9,072,321	B2	7/2015	Liu
9,072,322	B2	7/2015	Liu
9,078,472	B2	7/2015	Liu
9,078,474	B2	7/2015	Thompson
9,078,475	B2	7/2015	Li et al.
9,089,166	B1	7/2015	Scatterday
9,089,168	B2	7/2015	Liu
9,090,173	B2	7/2015	Oishi
D736,706	S	8/2015	Huang et al.
D736,995	S	8/2015	Recio
D737,508	S	8/2015	Liu
9,095,174	B2	8/2015	Capuano
9,095,175	B2	8/2015	Terry et al.
9,099,873	B2	8/2015	Xiang
9,101,729	B2	8/2015	Liu
9,113,659	B2	8/2015	Liu

(56) **References Cited**

U.S. PATENT DOCUMENTS

D737,566 S 9/2015 Gaddis
D738,038 S 9/2015 Smith
D739,973 S 9/2015 Chao
9,131,733 B2 9/2015 Liu
D741,001 S 10/2015 Alarcon et al.
D741,002 S 10/2015 Liu
D741,541 S 10/2015 Liu
D742,063 S 10/2015 Recio
D742,064 S 10/2015 Leidel
9,155,336 B2 10/2015 Liu
9,166,424 B2 10/2015 Oakley, Jr.
9,167,849 B2 10/2015 Adamic
9,167,850 B2 10/2015 Liu
9,167,852 B2 10/2015 Xiu
9,167,853 B2 10/2015 Xiang
D742,492 S 11/2015 Robinson et al.
D742,624 S 11/2015 Meyers
D743,099 S 11/2015 Oglesby
D744,159 S 11/2015 Lukas
9,185,937 B2 11/2015 Liu
9,197,726 B2 11/2015 Stanimirovic et al.
D744,342 S 12/2015 Blasko et al.
D744,419 S 12/2015 Bowen et al.
D744,696 S 12/2015 Malhi
D745,004 S 12/2015 Kim
D745,388 S 12/2015 Taylor
D746,291 S 12/2015 Solomon et al.
9,198,463 B2 12/2015 Liu
9,198,464 B2 12/2015 Liu
9,198,466 B2 12/2015 Liu
9,204,670 B2 12/2015 Liu
9,215,895 B2 12/2015 Bowen et al.
9,220,302 B2 12/2015 DePiano et al.
9,220,303 B2 12/2015 Li et al.
D747,035 S 1/2016 Moradian
D747,265 S 1/2016 Marini
D747,546 S 1/2016 Liu
D747,603 S 1/2016 Gaddis
D747,722 S 1/2016 Webb
D747,852 S 1/2016 Meyers
D748,329 S 1/2016 Bagai et al.
9,226,525 B2 1/2016 Liu
9,226,526 B2 1/2016 Liu
9,233,217 B2 1/2016 Jones
9,240,695 B2 1/2016 Xiang
9,240,697 B2 1/2016 Xiang
D748,852 S 2/2016 Wu
D748,853 S 2/2016 Seibel et al.
D749,260 S 2/2016 Wu
D749,261 S 2/2016 Chen
D749,505 S 2/2016 Verleur et al.
D749,510 S 2/2016 Liu
D749,781 S 2/2016 Lane
D750,320 S 2/2016 Verleur et al.
D750,321 S 2/2016 Chen
9,254,002 B2 2/2016 Chong et al.
9,254,005 B2 2/2016 Liu
9,255,277 B2 2/2016 Bakker et al.
D750,835 S 3/2016 Wei
D751,250 S 3/2016 Vuong
D751,527 S 3/2016 Hinokio et al.
D751,755 S 3/2016 Van Riper
D751,757 S 3/2016 Stern
D752,277 S 3/2016 Liu
D752,278 S 3/2016 Verleur et al.
D752,279 S 3/2016 Liu
D752,280 S 3/2016 Verleur et al.
D752,282 S 3/2016 Doster
D752,283 S 3/2016 Doster
D752,284 S 3/2016 Doster
D752,285 S 3/2016 Doster
D752,286 S 3/2016 Doster
D752,808 S 3/2016 Hearn
9,271,525 B2 3/2016 Liu
9,271,526 B2 3/2016 Liu
9,271,529 B2 3/2016 Alima
9,272,103 B2 3/2016 Storz
9,277,768 B2 3/2016 Xiu
9,277,769 B2 3/2016 Liu
9,281,705 B2 3/2016 Xiang
9,282,772 B2 3/2016 Tucker et al.
9,282,773 B2 3/2016 Greim et al.
9,289,014 B2 3/2016 Tucker et al.
9,295,286 B2 3/2016 Shin
D753,090 S 4/2016 Langhammer et al.
D753,338 S 4/2016 Chen
D753,873 S 4/2016 Schuessler
D753,874 S 4/2016 Moreno Medina et al.
D754,919 S 4/2016 Alarcon et al.
9,301,545 B2 4/2016 Li et al.
9,301,549 B2 4/2016 Liu
9,302,800 B2 4/2016 Holmes et al.
9,302,825 B2 4/2016 Liu
9,308,336 B2 4/2016 Newton
9,312,687 B2 4/2016 Xiang
9,315,890 B1 4/2016 Frick et al.
9,320,300 B2 4/2016 Hon
D755,057 S 5/2016 Mutter
D755,506 S 5/2016 Neely Ill et al.
D755,733 S 5/2016 Ikegaya et al.
D755,735 S 5/2016 Kashimoto
D756,030 S 5/2016 Chen
D756,031 S 5/2016 Wu
D756,559 S 5/2016 Li
D757,352 S 5/2016 Bagai
D757,353 S 5/2016 Nunnelly et al.
D757,690 S 5/2016 Lee et al.
D757,994 S 5/2016 Moradian
D757,995 S 5/2016 Liu
9,326,547 B2 5/2016 Tucker et al.
9,326,549 B2 5/2016 Hon
9,332,787 B2 5/2016 Liu
9,345,269 B2 5/2016 Liu
9,350,102 B2 5/2016 Wu
9,350,178 B2 5/2016 Xiang
9,350,181 B2 5/2016 Xiang
9,351,522 B2 5/2016 Safari
D758,647 S 6/2016 Liu
D758,649 S 6/2016 Liu
D758,650 S 6/2016 Wu
D759,031 S 6/2016 Ozolins et al.
D759,297 S 6/2016 Liu
D759,303 S 6/2016 Afridi
D760,431 S 6/2016 Liu
9,357,802 B2 6/2016 Liu
9,360,379 B2 6/2016 Liu
9,364,025 B2 6/2016 Liu
9,364,026 B2 6/2016 Liu
9,364,027 B2 6/2016 Hon
9,364,800 B2 6/2016 Dubief
9,379,364 B2 6/2016 Alima
D760,952 S 7/2016 Mayor
D761,488 S 7/2016 Alarcon et al.
D761,999 S 7/2016 Liu
D762,000 S 7/2016 Liu
D762,001 S 7/2016 Liu
D762,003 S 7/2016 Lomeli
D762,326 S 7/2016 Liu
9,380,810 B2 7/2016 Rose et al.
9,380,812 B2 7/2016 Chung
9,383,053 B2 7/2016 Liu
9,385,554 B2 7/2016 Xiang
9,386,803 B2 7/2016 Burke et al.
D763,203 S 8/2016 Ikegaya et al.
D763,204 S 8/2016 Ikegaya et al.
D763,502 S 8/2016 Verleur et al.
D764,098 S 8/2016 Liu
D764,703 S 8/2016 Liu
D765,307 S 8/2016 Liu
D765,308 S 8/2016 Liu
D765,309 S 8/2016 Liu
9,408,416 B2 8/2016 Monsees et al.
9,413,180 B2 8/2016 Liu
9,414,627 B2 8/2016 Liu

(56) **References Cited**

U.S. PATENT DOCUMENTS

9,414,628	B2	8/2016	Liu
9,415,929	B2	8/2016	Liu
9,417,107	B2	8/2016	Xiang
9,420,831	B2	8/2016	Liu
9,427,022	B2	8/2016	Levin et al.
9,427,023	B2	8/2016	Liu
9,427,024	B2	8/2016	Liu
9,427,025	B2	8/2016	Liu
9,427,026	B2	8/2016	Wu
D765,907	S	9/2016	Liu
D766,503	S	9/2016	Liu
D766,873	S	9/2016	Washio
D767,200	S	9/2016	Liu
D767,201	S	9/2016	Starr
D767,820	S	9/2016	Jordan et al.
D767,822	S	9/2016	Jordan et al.
9,433,242	B1	9/2016	Buffone
9,438,049	B2	9/2016	Xiang
9,438,051	B2	9/2016	Firman, II et al.
9,439,455	B2	9/2016	Alarcon et al.
9,439,456	B2	9/2016	Liu
9,440,035	B2	9/2016	Chung
9,451,790	B2	9/2016	Liu
9,451,793	B2	9/2016	Zhou
9,455,579	B2	9/2016	Xiang
D768,331	S	10/2016	Chen
D768,920	S	10/2016	Jones et al.
D768,980	S	10/2016	Alexander
D769,518	S	10/2016	Liu
D769,519	S	10/2016	Chen
D769,520	S	10/2016	Hua
D769,830	S	10/2016	Clymer et al.
D770,088	S	10/2016	Abadi et al.
9,456,632	B2	10/2016	Hon
9,456,633	B2	10/2016	Liu
9,456,634	B2	10/2016	Wang et al.
9,459,021	B2	10/2016	Greim et al.
9,462,832	B2	10/2016	Lord
9,465,081	B2	10/2016	Xiang
9,474,305	B2	10/2016	Liu
D770,395	S	11/2016	Clymer et al.
D770,676	S	11/2016	Bennett et al.
D770,678	S	11/2016	Shin
D770,679	S	11/2016	Weigensberg
D771,219	S	11/2016	Gilbarte
D771,307	S	11/2016	Wu
D771,308	S	11/2016	Saydar et al.
D772,477	S	11/2016	Shin
D772,478	S	11/2016	Liu
D772,479	S	11/2016	Stowers et al.
D772,480	S	11/2016	Hua
D772,879	S	11/2016	Eliyahu
D773,114	S	11/2016	Leidel et al.
D773,115	S	11/2016	Liu
D773,116	S	11/2016	Liu et al.
9,480,285	B2	11/2016	Liu
9,480,286	B2	11/2016	Liu
9,497,993	B2	11/2016	Vallar
9,497,994	B2	11/2016	Liu
9,497,995	B2	11/2016	Liu
9,497,997	B2	11/2016	Wu
9,497,998	B2	11/2016	Chen
9,497,999	B2	11/2016	Lord
9,498,001	B2	11/2016	Wu
9,498,002	B1	11/2016	Soreide
9,498,588	B2	11/2016	Benassayag et al.
9,502,917	B2	11/2016	Xiang
9,504,278	B2	11/2016	Liu
9,504,279	B2	11/2016	Chen
D773,391	S	12/2016	Haarburger et al.
D773,727	S	12/2016	Eksouzian
D773,729	S	12/2016	Jordan et al.
D774,247	S	12/2016	Chen
D774,248	S	12/2016	Jordan et al.
D774,514	S	12/2016	Turksu et al.
D774,693	S	12/2016	Liu
D774,892	S	12/2016	Liu
D775,412	S	12/2016	Di Bari
D775,413	S	12/2016	Liu
9,510,624	B2	12/2016	Li et al.
9,516,898	B2	12/2016	Liu
9,521,867	B2	12/2016	Xiang
9,526,272	B2	12/2016	Liu
9,526,273	B2	12/2016	Liu
9,531,183	B2	12/2016	Xiang
D776,051	S	1/2017	Wang
D776,162	S	1/2017	Beck et al.
D776,270	S	1/2017	Wilcox et al.
D776,338	S	1/2017	Lomeli
D776,340	S	1/2017	Seibel et al.
D776,659	S	1/2017	Hou
D777,372	S	1/2017	Liu
D777,976	S	1/2017	Mahlmeister
9,532,598	B2	1/2017	Liu
9,532,599	B2	1/2017	Liu
9,532,601	B2	1/2017	Liu
9,532,602	B2	1/2017	Liu
9,532,604	B2	1/2017	Conley et al.
9,532,605	B2	1/2017	Yamada et al.
9,538,781	B2	1/2017	Zheng
9,538,783	B2	1/2017	Xiang
9,538,787	B2	1/2017	Liu
9,538,789	B2	1/2017	Liu
9,545,489	B2	1/2017	Turner et al.
9,549,572	B2	1/2017	Dincer et al.
9,549,573	B2	1/2017	Monsees et al.
9,554,596	B2	1/2017	Liu
9,554,597	B2	1/2017	Liu
9,555,203	B2	1/2017	Terry et al.
D778,493	S	2/2017	Scott
D778,831	S	2/2017	Chen
D779,677	S	2/2017	Chen
D779,719	S	2/2017	Qiu
D780,179	S	2/2017	Bae et al.
D780,372	S	2/2017	Liu
9,560,882	B2	2/2017	Xiang
9,565,873	B2	2/2017	Zheng
9,565,876	B2	2/2017	Tsai
9,572,372	B2	2/2017	Liu
9,572,373	B2	2/2017	Chen
9,572,374	B2	2/2017	Gabbay
9,573,751	B2	2/2017	Liu
9,578,002	B2	2/2017	Wu
9,578,898	B2	2/2017	Liu
D780,990	S	3/2017	Liu
D780,991	S	3/2017	Liu
D782,108	S	3/2017	Jordan et al.
D782,728	S	3/2017	Pinder
D782,729	S	3/2017	Wright et al.
9,591,876	B2	3/2017	Alima
9,596,881	B2	3/2017	Chiolini et al.
9,596,884	B2	3/2017	Liu
9,596,885	B2	3/2017	Liu
9,596,886	B2	3/2017	Liu
9,596,887	B2	3/2017	Newton
9,602,646	B2	3/2017	Stanimirovic et al.
9,603,198	B2	3/2017	Liu
9,603,386	B2	3/2017	Xiang
9,603,387	B2	3/2017	Liu
9,603,389	B2	3/2017	Chen
9,603,390	B2	3/2017	Li et al.
D784,609	S	4/2017	Liu
D785,234	S	4/2017	Liu
D785,237	S	4/2017	Wu
9,609,893	B2	4/2017	Novak, III et al.
9,615,605	B2	4/2017	Liu
9,615,606	B2	4/2017	Liu
9,615,607	B2	4/2017	Liu
9,620,958	B2	4/2017	Liu
9,622,511	B2	4/2017	Zhu
9,623,592	B2	4/2017	Liu
9,627,661	B2	4/2017	Liu
9,629,391	B2	4/2017	Dube et al.
9,629,394	B2	4/2017	Aronie et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

D785,859 S 5/2017 Pang
D785,862 S 5/2017 Wu
D786,789 S 5/2017 Jordan et al.
D787,114 S 5/2017 Scott
D788,362 S 5/2017 Qiu
9,635,886 B2 5/2017 Tu
9,641,208 B2 5/2017 Sela et al.
9,642,396 B2 5/2017 Liu
9,642,397 B2 5/2017 Dai et al.
9,645,134 B1 5/2017 Farmen et al.
9,648,905 B2 5/2017 Levitz et al.
9,648,908 B1 5/2017 Rinehart et al.
9,648,909 B2 5/2017 Zhou et al.
9,655,383 B2 5/2017 Holzherr et al.
9,655,890 B2 5/2017 Hearn et al.
9,661,878 B2 5/2017 Liu
9,663,266 B2 5/2017 Schwester
D788,697 S 6/2017 Verleur et al.
D790,122 S 6/2017 Hawes et al.
D790,126 S 6/2017 Bennett et al.
D790,129 S 6/2017 Bennett et al.
D790,766 S 6/2017 Li
9,668,517 B2 6/2017 Liu
9,668,518 B2 6/2017 Esses
9,668,519 B2 6/2017 Mishra et al.
9,668,520 B2 6/2017 Boldrini
9,668,521 B2 6/2017 Kuczaj
9,668,522 B2 6/2017 Memari et al.
9,668,523 B2 6/2017 Tucker et al.
9,675,108 B2 6/2017 Liu
9,675,113 B2 6/2017 Liu
9,675,114 B2 6/2017 Timmermans
9,675,115 B2 6/2017 Liu
9,675,116 B2 6/2017 Liu
9,675,117 B2 6/2017 Li et al.
9,675,118 B2 6/2017 Chen
9,681,687 B2 6/2017 Liu
9,681,688 B1 6/2017 Rinehart et al.
9,682,203 B2 6/2017 Dahne et al.
9,682,204 B2 6/2017 Matsumoto et al.
9,682,800 B2 6/2017 Xiang
9,687,025 B2 6/2017 Cyphert et al.
9,687,027 B2 6/2017 Poston et al.
9,687,028 B2 6/2017 Park
9,687,029 B2 6/2017 Liu
D792,021 S 7/2017 Beer et al.
D792,022 S 7/2017 Li
D792,644 S 7/2017 Jordan et al.
D793,004 S 7/2017 Liu
9,693,584 B2 7/2017 Hearn et al.
9,693,586 B2 7/2017 Liu
9,693,587 B2 7/2017 Plojoux et al.
9,693,588 B2 7/2017 Zhu
9,695,033 B1 7/2017 Alshouse et al.
9,700,074 B2 7/2017 Liu
9,700,075 B2 7/2017 Liu
9,700,076 B2 7/2017 Xiang
9,713,345 B2 7/2017 Farine et al.
9,713,346 B2 7/2017 Hon
9,714,878 B2 7/2017 Powers et al.
D793,620 S 8/2017 Bennett et al.
9,717,274 B2 8/2017 Daehne et al.
9,717,275 B2 8/2017 Liu
9,717,276 B2 8/2017 Brammer et al.
9,717,277 B2 8/2017 Mironov
9,717,278 B2 8/2017 Hon
9,717,279 B2 8/2017 Hon
9,723,872 B2 8/2017 Liu
9,723,873 B2 8/2017 Liu
9,723,874 B2 8/2017 Liu
9,723,875 B2 8/2017 Liu
9,723,876 B2 8/2017 Cadieux et al.
9,723,877 B2 8/2017 Wong et al.
9,730,471 B2 8/2017 Li et al.
9,738,622 B2 8/2017 Dull et al.
9,763,478 B2 9/2017 Cameron et al.
9,770,055 B2 9/2017 Cameron et al.
D799,746 S 10/2017 Leidel et al.
9,775,380 B2 10/2017 Fernando et al.
9,802,011 B2 10/2017 Davidson et al.
9,806,549 B2 10/2017 Liberti et al.
D802,206 S 11/2017 Huang et al.
9,809,567 B2 11/2017 Willis et al.
9,814,263 B2 11/2017 Cochand et al.
9,814,272 B2 11/2017 Li et al.
9,820,508 B2 11/2017 Arnel et al.
D806,311 S 12/2017 Smith
2001/0015209 A1 8/2001 Zielke
2001/0032643 A1 10/2001 Hochrainer et al.
2001/0032795 A1 10/2001 Weinstein et al.
2001/0052480 A1 12/2001 Kawaguchi et al.
2002/0029779 A1 3/2002 Schmidt et al.
2002/0043554 A1 4/2002 White et al.
2002/0078951 A1 6/2002 Nichols et al.
2002/0088469 A1 7/2002 Rennecamp
2002/0142291 A1 10/2002 Bauer et al.
2002/0175164 A1 11/2002 Dees et al.
2003/0004426 A1 1/2003 Melker et al.
2003/0005926 A1 1/2003 Jones et al.
2003/0089377 A1 5/2003 Hajaligol et al.
2003/0149372 A1 8/2003 Smith et al.
2003/0150451 A1 8/2003 Shayan
2003/0154991 A1 8/2003 Fournier et al.
2004/0031495 A1 2/2004 Steinberg
2004/0050382 A1 3/2004 Goodchild
2004/0099266 A1 5/2004 Cross et al.
2004/0129280 A1 7/2004 Woodson et al.
2004/0149296 A1 8/2004 Rostami et al.
2004/0149624 A1 8/2004 Wischusen et al.
2004/0173224 A1 9/2004 Burgard et al.
2004/0173229 A1 9/2004 Crooks et al.
2004/0182403 A1 9/2004 Andersson et al.
2004/0191322 A1 9/2004 Hansson
2004/0221857 A1 11/2004 Dominguez
2004/0226569 A1 11/2004 Yang et al.
2004/0237974 A1 12/2004 Min
2005/0016549 A1 1/2005 Banerjee et al.
2005/0016550 A1 1/2005 Katase
2005/0029137 A1 2/2005 Wang
2005/0034723 A1 2/2005 Bennett et al.
2005/0061759 A1 3/2005 Doucette
2005/0069831 A1 3/2005 St. Charles et al.
2005/0081601 A1 4/2005 Lawson
2005/0090798 A1 4/2005 Clark et al.
2005/0118545 A1 6/2005 Wong
2005/0145533 A1 7/2005 Seligson
2005/0172976 A1 8/2005 Newman et al.
2005/0229918 A1 10/2005 Shim
2005/0236006 A1 10/2005 Cowan
2005/0244521 A1 11/2005 Strickland et al.
2005/0268911 A1 12/2005 Cross et al.
2006/0016453 A1 1/2006 Kim
2006/0018840 A1 1/2006 Lechuga-Ballesteros et al.
2006/0054676 A1 3/2006 Wischusen
2006/0102175 A1 5/2006 Nelson
2006/0150991 A1 7/2006 Lee
2006/0185687 A1 8/2006 Hearn et al.
2006/0191546 A1 8/2006 Takano et al.
2006/0191548 A1 8/2006 Strickland et al.
2006/0196518 A1 9/2006 Hon
2006/0254948 A1 11/2006 Herbert et al.
2006/0255105 A1 11/2006 Sweet
2007/0006889 A1 1/2007 Kobal et al.
2007/0045288 A1 3/2007 Nelson
2007/0062548 A1 3/2007 Horstmann et al.
2007/0074734 A1 4/2007 Braunshteyn et al.
2007/0089757 A1 4/2007 Bryman
2007/0098148 A1 5/2007 Sherman
2007/0102013 A1 5/2007 Adams et al.
2007/0125765 A1 6/2007 Nelson
2007/0144514 A1 6/2007 Yeates et al.
2007/0163610 A1 7/2007 Lindell et al.
2007/0191756 A1 8/2007 Tapper
2007/0215164 A1 9/2007 Mehio

(56) **References Cited**

U.S. PATENT DOCUMENTS

2007/0215168 A1 9/2007 Banerjee et al.
2007/0235046 A1 10/2007 Gedevanishvili
2007/0267033 A1 11/2007 Mishra et al.
2007/0277816 A1 12/2007 Morrison et al.
2007/0280652 A1 12/2007 Williams
2007/0283972 A1 12/2007 Monsees et al.
2007/0295347 A1 12/2007 Paine et al.
2008/0000763 A1 1/2008 Cove
2008/0023003 A1 1/2008 Rosenthal
2008/0029095 A1 2/2008 Esser
2008/0092912 A1 4/2008 Robinson et al.
2008/0138423 A1 6/2008 Gonda
2008/0149118 A1 6/2008 Oglesby et al.
2008/0207276 A1 8/2008 Burrell
2008/0216828 A1 9/2008 Wensley et al.
2008/0241255 A1 10/2008 Rose et al.
2008/0257367 A1 10/2008 Paterno et al.
2008/0276947 A1 11/2008 Martzel
2008/0286340 A1 11/2008 Andersson et al.
2008/0302375 A1 12/2008 Andersson et al.
2009/0004249 A1 1/2009 Gonda
2009/0095287 A1 4/2009 Emarlou
2009/0095311 A1 4/2009 Han
2009/0111287 A1 4/2009 Lindberg et al.
2009/0126745 A1 5/2009 Hon
2009/0133691 A1 5/2009 Yamada et al.
2009/0133703 A1 5/2009 Strickland et al.
2009/0133704 A1 5/2009 Strickland et al.
2009/0151717 A1 6/2009 Bowen et al.
2009/0188490 A1 7/2009 Han
2009/0230117 A1 9/2009 Fernando et al.
2009/0255534 A1 10/2009 Paterno
2009/0260641 A1 10/2009 Monsees et al.
2009/0260642 A1 10/2009 Monsees et al.
2009/0267252 A1 10/2009 Ikeyama
2009/0272379 A1 11/2009 Thorens et al.
2009/0283103 A1 11/2009 Nielsen et al.
2009/0288668 A1 11/2009 Inagaki
2009/0288669 A1 11/2009 Hutchens
2009/0293892 A1 12/2009 Williams et al.
2009/0293895 A1 12/2009 Axelsson et al.
2010/0000672 A1 1/2010 Fogle
2010/0006092 A1 1/2010 Hale et al.
2010/0024834 A1 2/2010 Oglesby et al.
2010/0031968 A1 2/2010 Sheikh et al.
2010/0059073 A1 3/2010 Hoffmann et al.
2010/0156193 A1 6/2010 Rhodes et al.
2010/0163063 A1 7/2010 Fernando et al.
2010/0163065 A1 7/2010 Chang
2010/0186757 A1 7/2010 Crooks et al.
2010/0200006 A1 8/2010 Robinson et al.
2010/0200008 A1 8/2010 Taieb
2010/0236562 A1 9/2010 Hearn et al.
2010/0242974 A1 9/2010 Pan
2010/0242976 A1 9/2010 Katayama et al.
2010/0275938 A1 11/2010 Roth et al.
2010/0276333 A1 11/2010 Couture
2010/0307116 A1 12/2010 Fisher
2010/0307518 A1 12/2010 Wang
2010/0313901 A1 12/2010 Fernando et al.
2011/0005535 A1 1/2011 Xiu
2011/0011396 A1 1/2011 Fang
2011/0030706 A1 2/2011 Gibson et al.
2011/0036346 A1 2/2011 Cohen et al.
2011/0036363 A1 2/2011 Urtsev et al.
2011/0041861 A1 2/2011 Sebastian et al.
2011/0049226 A1 3/2011 Moreau et al.
2011/0083684 A1 4/2011 Luan et al.
2011/0094523 A1 4/2011 Thorens et al.
2011/0097060 A1 4/2011 Michael Buzzetti
2011/0108023 A1 5/2011 McKinney et al.
2011/0120482 A1 5/2011 Brenneise
2011/0126831 A1 6/2011 Fernandez Pernia
2011/0155151 A1 6/2011 Newman et al.
2011/0155153 A1 6/2011 Thorens et al.
2011/0162667 A1 7/2011 Burke et al.
2011/0168194 A1 7/2011 Hon
2011/0180433 A1 7/2011 Rennecamp
2011/0192397 A1 8/2011 Saskar et al.
2011/0226236 A1 9/2011 Buchberger
2011/0226266 A1 9/2011 Tao
2011/0232654 A1 9/2011 Mass
2011/0232655 A1 9/2011 Chan et al.
2011/0236002 A1 9/2011 Oglesby et al.
2011/0240047 A1 10/2011 Adamic
2011/0263947 A1 10/2011 Utley et al.
2011/0265806 A1 11/2011 Alarcon et al.
2011/0268809 A1 11/2011 Brinkley et al.
2011/0277780 A1 11/2011 Terry et al.
2011/0278189 A1 11/2011 Terry et al.
2011/0290248 A1 12/2011 Schennum
2011/0290269 A1 12/2011 Shimizu
2011/0293535 A1 12/2011 Kosik et al.
2011/0308521 A1 12/2011 Kofford
2011/0315152 A1 12/2011 Hearn et al.
2011/0315701 A1 12/2011 Everson
2012/0006342 A1 1/2012 Rose et al.
2012/0060853 A1 3/2012 Robinson et al.
2012/0077849 A1 3/2012 Howson et al.
2012/0086391 A1 4/2012 Smith
2012/0111346 A1 5/2012 Rinker et al.
2012/0111347 A1 5/2012 Hon
2012/0118301 A1 5/2012 Montaser
2012/0118307 A1 5/2012 Tu
2012/0125353 A1 5/2012 Wollin
2012/0138052 A1 6/2012 Hearn et al.
2012/0174914 A1 7/2012 Pirshafiey et al.
2012/0199146 A1 8/2012 Marangos
2012/0199663 A1 8/2012 Qiu
2012/0204889 A1 8/2012 Xiu
2012/0211015 A1 8/2012 Li et al.
2012/0227753 A1 9/2012 Newton
2012/0234315 A1 9/2012 Li et al.
2012/0234821 A1 9/2012 Shimizu
2012/0247494 A1 10/2012 Oglesby et al.
2012/0255567 A1 10/2012 Rose et al.
2012/0260926 A1 10/2012 Tu et al.
2012/0260927 A1 10/2012 Liu
2012/0261286 A1 10/2012 Holloway et al.
2012/0267383 A1 10/2012 Van Rooyen
2012/0279512 A1 11/2012 Hon
2012/0285475 A1 11/2012 Liu
2012/0291791 A1 11/2012 Pradeep
2012/0298676 A1 11/2012 Cooks
2012/0312313 A1 12/2012 Frija
2012/0318882 A1 12/2012 Abehasera
2012/0325227 A1 12/2012 Robinson et al.
2012/0325228 A1 12/2012 Williams
2013/0008457 A1 1/2013 Zheng et al.
2013/0014755 A1 1/2013 Kumar et al.
2013/0014772 A1 1/2013 Liu
2013/0019887 A1 1/2013 Liu
2013/0023850 A1 1/2013 Imran et al.
2013/0025609 A1 1/2013 Liu
2013/0037041 A1 2/2013 Worm et al.
2013/0042865 A1 2/2013 Monsees et al.
2013/0047984 A1 2/2013 Dahne et al.
2013/0056012 A1 3/2013 Hearn et al.
2013/0056013 A1 3/2013 Terry et al.
2013/0068239 A1 3/2013 Youn
2013/0074857 A1 3/2013 Buchberger
2013/0081642 A1 4/2013 Safari
2013/0087160 A1 4/2013 Gherghe
2013/0140200 A1 6/2013 Scatterday
2013/0146489 A1 6/2013 Scatterday
2013/0152922 A1 6/2013 Benassayag et al.
2013/0152954 A1 6/2013 Youn
2013/0167854 A1 7/2013 Shin
2013/0168880 A1 7/2013 Duke
2013/0186416 A1 7/2013 Gao et al.
2013/0192618 A1 8/2013 Li et al.
2013/0192619 A1 8/2013 Tucker et al.
2013/0199528 A1 8/2013 Goodman et al.
2013/0213417 A1 8/2013 Chong et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2013/0213418 A1 8/2013 Tucker et al.
2013/0213419 A1 8/2013 Tucker et al.
2013/0220315 A1 8/2013 Conley et al.
2013/0220847 A1 8/2013 Fisher et al.
2013/0228190 A1 9/2013 Weiss et al.
2013/0228191 A1 9/2013 Newton
2013/0233086 A1 9/2013 Besling et al.
2013/0247924 A1 9/2013 Scatterday et al.
2013/0248385 A1 9/2013 Scatterday et al.
2013/0255702 A1 10/2013 Griffith, Jr. et al.
2013/0263869 A1 10/2013 Zhu
2013/0276802 A1 10/2013 Scatterday
2013/0284190 A1 10/2013 Scatterday et al.
2013/0284191 A1 10/2013 Scatterday et al.
2013/0284192 A1 10/2013 Peleg et al.
2013/0298905 A1 11/2013 Levin et al.
2013/0306065 A1 11/2013 Thorens et al.
2013/0312742 A1 11/2013 Monsees et al.
2013/0319431 A1 12/2013 Cyphert et al.
2013/0319435 A1 12/2013 Flick
2013/0319436 A1 12/2013 Liu
2013/0319437 A1 12/2013 Liu
2013/0319439 A1 12/2013 Gorelick et al.
2013/0319440 A1 12/2013 Capuano
2013/0333700 A1 12/2013 Buchberger
2013/0333711 A1 12/2013 Liu
2013/0336358 A1 12/2013 Liu
2013/0340775 A1 12/2013 Juster et al.
2013/0342157 A1 12/2013 Liu
2014/0000638 A1 1/2014 Sebastian et al.
2014/0007891 A1 1/2014 Liu
2014/0007892 A1 1/2014 Liu
2014/0014124 A1 1/2014 Glasberg et al.
2014/0014126 A1 1/2014 Peleg et al.
2014/0020697 A1 1/2014 Liu
2014/0034071 A1 2/2014 Levitz et al.
2014/0035391 A1 2/2014 Kitani
2014/0041655 A1 2/2014 Barron et al.
2014/0041658 A1 2/2014 Goodman et al.
2014/0048086 A1 2/2014 Zhanghua
2014/0053856 A1 2/2014 Liu
2014/0053858 A1 2/2014 Liu
2014/0060528 A1 3/2014 Liu
2014/0060529 A1 3/2014 Zhang
2014/0060552 A1 3/2014 Cohen
2014/0060556 A1 3/2014 Liu
2014/0062417 A1 3/2014 Li et al.
2014/0069424 A1 3/2014 Poston et al.
2014/0069425 A1 3/2014 Zhang
2014/0083442 A1 3/2014 Scatterday
2014/0096782 A1 4/2014 Ampolini et al.
2014/0107815 A1 4/2014 LaMothe
2014/0109898 A1 4/2014 Li et al.
2014/0109921 A1 4/2014 Chen
2014/0116455 A1 5/2014 Youn
2014/0123989 A1 5/2014 LaMothe
2014/0123990 A1 5/2014 Timmermans
2014/0130796 A1 5/2014 Liu
2014/0130797 A1 5/2014 Liu
2014/0130816 A1 5/2014 Liu
2014/0130817 A1 5/2014 Li et al.
2014/0144429 A1 5/2014 Wensley et al.
2014/0144453 A1 5/2014 Capuano et al.
2014/0150784 A1 6/2014 Liu
2014/0150785 A1 6/2014 Malik et al.
2014/0150810 A1 6/2014 Hon
2014/0161301 A1 6/2014 Merenda
2014/0166028 A1 6/2014 Fuisz et al.
2014/0166029 A1 6/2014 Weigensberg et al.
2014/0166030 A1 6/2014 Li et al.
2014/0166032 A1 6/2014 Gindrat
2014/0174458 A1 6/2014 Katz
2014/0174459 A1 6/2014 Burstyn
2014/0175081 A1 6/2014 Hwa
2014/0178461 A1 6/2014 Rigas
2014/0182609 A1 7/2014 Liu
2014/0182610 A1 7/2014 Liu
2014/0182611 A1 7/2014 Liu
2014/0182612 A1 7/2014 Chen
2014/0190477 A1 7/2014 Qiu
2014/0190478 A1 7/2014 Liu
2014/0190496 A1 7/2014 Wensley et al.
2014/0190501 A1 7/2014 Liu
2014/0190502 A1 7/2014 Liu
2014/0190503 A1 7/2014 Li et al.
2014/0196716 A1 7/2014 Liu
2014/0196718 A1 7/2014 Li et al.
2014/0196731 A1 7/2014 Scatterday
2014/0196733 A1 7/2014 Liu
2014/0196734 A1 7/2014 Liu
2014/0196735 A1 7/2014 Liu
2014/0202474 A1 7/2014 Peleg et al.
2014/0202475 A1 7/2014 Liu
2014/0202477 A1 7/2014 Qi et al.
2014/0209096 A1 7/2014 Cheyene
2014/0209106 A1 7/2014 Liu
2014/0209107 A1 7/2014 Liu
2014/0209108 A1 7/2014 Li et al.
2014/0209109 A1 7/2014 Larson
2014/0216450 A1 8/2014 Liu
2014/0216483 A1 8/2014 Alima
2014/0216484 A1 8/2014 Liu
2014/0224244 A1 8/2014 Liu
2014/0224267 A1 8/2014 Levitz et al.
2014/0230835 A1 8/2014 Saliman
2014/0238421 A1 8/2014 Shapiro
2014/0238422 A1 8/2014 Plunkett et al.
2014/0238423 A1 8/2014 Tucker et al.
2014/0238424 A1 8/2014 Macko et al.
2014/0246031 A1 9/2014 Liu
2014/0246033 A1 9/2014 Daehne et al.
2014/0251324 A1 9/2014 Xiang
2014/0251325 A1 9/2014 Liu
2014/0251356 A1 9/2014 Xiang
2014/0253144 A1 9/2014 Novak, III et al.
2014/0254055 A1 9/2014 Xiang
2014/0259026 A1 9/2014 Xiang
2014/0261408 A1 9/2014 DePiano et al.
2014/0261474 A1 9/2014 Gonda
2014/0261479 A1 9/2014 Xu et al.
2014/0261483 A1 9/2014 Hopps
2014/0261486 A1 9/2014 Potter et al.
2014/0261487 A1 9/2014 Chapman et al.
2014/0261488 A1 9/2014 Tucker
2014/0261489 A1 9/2014 Cadieux et al.
2014/0261490 A1 9/2014 Kane
2014/0261491 A1 9/2014 Hawes
2014/0261492 A1 9/2014 Kane et al.
2014/0261493 A1 9/2014 Smith et al.
2014/0261494 A1 9/2014 Scatterday
2014/0261495 A1 9/2014 Novak, III et al.
2014/0261497 A1 9/2014 Liu
2014/0261498 A1 9/2014 Liu
2014/0261500 A1 9/2014 Park
2014/0270727 A1 9/2014 Ampolini et al.
2014/0270729 A1 9/2014 DePiano et al.
2014/0270730 A1 9/2014 DePiano et al.
2014/0271946 A1 9/2014 Kobal et al.
2014/0274940 A1 9/2014 Mishra et al.
2014/0276536 A1 9/2014 Estes
2014/0278250 A1 9/2014 Smith et al.
2014/0278258 A1 9/2014 Shafer
2014/0283823 A1 9/2014 Liu
2014/0283855 A1 9/2014 Hawes et al.
2014/0283856 A1 9/2014 Xiang
2014/0283857 A1 9/2014 Liu
2014/0283858 A1 9/2014 Liu
2014/0290673 A1 10/2014 Liu
2014/0290676 A1 10/2014 Liu
2014/0290677 A1 10/2014 Liu
2014/0299137 A1 10/2014 Kieckbusch et al.
2014/0299138 A1 10/2014 Xiang
2014/0299139 A1 10/2014 Liu
2014/0299140 A1 10/2014 Liu

(56) **References Cited**

U.S. PATENT DOCUMENTS

2014/0301721 A1 10/2014 Ruscio et al.
2014/0305450 A1 10/2014 Xiang
2014/0305451 A1 10/2014 Liu
2014/0305452 A1 10/2014 Liu
2014/0305454 A1 10/2014 Rinker et al.
2014/0311503 A1 10/2014 Liu
2014/0311504 A1 10/2014 Liu
2014/0311505 A1 10/2014 Liu
2014/0332016 A1 11/2014 Bellinger et al.
2014/0332017 A1 11/2014 Liu
2014/0332018 A1 11/2014 Liu
2014/0332019 A1 11/2014 Liu
2014/0332020 A1 11/2014 Li et al.
2014/0332022 A1 11/2014 Li et al.
2014/0334803 A1 11/2014 Li et al.
2014/0338680 A1 11/2014 Abramov et al.
2014/0338681 A1 11/2014 Liu
2014/0338682 A1 11/2014 Liu
2014/0338683 A1 11/2014 Liu
2014/0338684 A1 11/2014 Liu
2014/0338685 A1 11/2014 Amir
2014/0345631 A1 11/2014 Bowen et al.
2014/0345632 A1 11/2014 Scatterday
2014/0345633 A1 11/2014 Talon et al.
2014/0345635 A1 11/2014 Rabinowitz et al.
2014/0352177 A1 12/2014 Rehkemper
2014/0352705 A1 12/2014 Liu
2014/0352707 A1 12/2014 Liu
2014/0353856 A1 12/2014 Dubief
2014/0353867 A1 12/2014 Liu
2014/0354215 A1 12/2014 Xiang
2014/0355969 A1 12/2014 Stern
2014/0356607 A1 12/2014 Woodcock
2014/0360512 A1 12/2014 Xiang
2014/0360516 A1 12/2014 Liu
2014/0366894 A1 12/2014 Liu
2014/0366895 A1 12/2014 Li et al.
2014/0366896 A1 12/2014 Li et al.
2014/0366897 A1 12/2014 Liu
2014/0366898 A1 12/2014 Monsees et al.
2014/0366902 A1 12/2014 Chiolini et al.
2014/0373833 A1 12/2014 Liu
2014/0373855 A1 12/2014 Zheng
2014/0373858 A1 12/2014 Liu
2014/0376895 A1 12/2014 Han
2014/0378790 A1 12/2014 Cohen
2015/0000682 A1 1/2015 Liu
2015/0000683 A1 1/2015 Liu
2015/0007834 A1 1/2015 Liu
2015/0007835 A1 1/2015 Liu
2015/0007836 A1 1/2015 Li et al.
2015/0013692 A1 1/2015 Liu
2015/0013693 A1 1/2015 Fuisz et al.
2015/0013696 A1 1/2015 Plojoux et al.
2015/0013700 A1 1/2015 Liu
2015/0013701 A1 1/2015 Liu
2015/0013702 A1 1/2015 Liu
2015/0015187 A1 1/2015 Xiang
2015/0020822 A1 1/2015 Janardhan et al.
2015/0020823 A1 1/2015 Lipowicz et al.
2015/0020824 A1 1/2015 Bowen et al.
2015/0020825 A1 1/2015 Galloway et al.
2015/0020826 A1 1/2015 Liu
2015/0020827 A1 1/2015 Liu
2015/0020828 A1 1/2015 Liu
2015/0020829 A1 1/2015 Li
2015/0020830 A1 1/2015 Koller
2015/0020831 A1 1/2015 Weigensberg et al.
2015/0020833 A1 1/2015 Conley et al.
2015/0027454 A1 1/2015 Li et al.
2015/0027455 A1 1/2015 Peleg et al.
2015/0027456 A1 1/2015 Janardhan et al.
2015/0027457 A1 1/2015 Janardhan et al.
2015/0027460 A1 1/2015 Liu
2015/0027461 A1 1/2015 Liu
2015/0027462 A1 1/2015 Liu
2015/0027463 A1 1/2015 Liu
2015/0027464 A1 1/2015 Liu
2015/0027465 A1 1/2015 Liu
2015/0027466 A1 1/2015 Xiang
2015/0027467 A1 1/2015 Liu
2015/0027468 A1 1/2015 Li et al.
2015/0027469 A1 1/2015 Tucker et al.
2015/0027470 A1 1/2015 Kane et al.
2015/0027471 A1 1/2015 Feldman et al.
2015/0027472 A1 1/2015 Amir
2015/0027473 A1 1/2015 Graf
2015/0034102 A1 2/2015 Faramarzian
2015/0034103 A1 2/2015 Hon
2015/0034104 A1 2/2015 Zhou
2015/0034105 A1 2/2015 Liu
2015/0034106 A1 2/2015 Liu
2015/0034107 A1 2/2015 Liu
2015/0034507 A1 2/2015 Liu
2015/0035540 A1 2/2015 Xiang
2015/0038567 A1 2/2015 Herkenroth et al.
2015/0040927 A1 2/2015 Li et al.
2015/0040928 A1 2/2015 Saydar et al.
2015/0040929 A1 2/2015 Hon
2015/0041482 A1 2/2015 Liu
2015/0047658 A1 2/2015 Cyphert et al.
2015/0047659 A1 2/2015 Liu
2015/0047660 A1 2/2015 Liu
2015/0047661 A1 2/2015 Blackley et al.
2015/0047663 A1 2/2015 Liu
2015/0053215 A1 2/2015 Liu
2015/0053216 A1 2/2015 Liu
2015/0053217 A1 2/2015 Steingraber et al.
2015/0053220 A1 2/2015 Levy et al.
2015/0057341 A1 2/2015 Perry
2015/0059779 A1 3/2015 Alarcon et al.
2015/0059780 A1 3/2015 Davis et al.
2015/0059782 A1 3/2015 Liu
2015/0059783 A1 3/2015 Liu
2015/0059784 A1 3/2015 Liu
2015/0059785 A1 3/2015 Liu
2015/0068523 A1 3/2015 Powers et al.
2015/0068543 A1 3/2015 Liu
2015/0068545 A1 3/2015 Moldoveanu et al.
2015/0075545 A1 3/2015 Xiang
2015/0075546 A1 3/2015 Kueny, Sr. et al.
2015/0078735 A1 3/2015 Cormack
2015/0080265 A1 3/2015 Elzinga et al.
2015/0082859 A1 3/2015 Xiang
2015/0083144 A1 3/2015 Xiang
2015/0083145 A1 3/2015 Li et al.
2015/0083146 A1 3/2015 Goldman et al.
2015/0083147 A1 3/2015 Schiff et al.
2015/0090256 A1 4/2015 Chung
2015/0090277 A1 4/2015 Xiang
2015/0090278 A1 4/2015 Schiff et al.
2015/0090279 A1 4/2015 Chen
2015/0090280 A1 4/2015 Chen
2015/0090281 A1 4/2015 Chen
2015/0100441 A1 4/2015 Alarcon et al.
2015/0101606 A1 4/2015 White
2015/0101622 A1 4/2015 Liu
2015/0101623 A1 4/2015 Liu
2015/0101625 A1 4/2015 Newton et al.
2015/0101626 A1 4/2015 Li et al.
2015/0101945 A1 4/2015 Scatterday
2015/0102777 A1 4/2015 Cooper
2015/0105455 A1 4/2015 Bjorncrantz
2015/0107609 A1 4/2015 Liu
2015/0107610 A1 4/2015 Metrangolo et al.
2015/0107611 A1 4/2015 Metrangolo et al.
2015/0107612 A1 4/2015 Liu
2015/0108019 A1 4/2015 Liu
2015/0114407 A1 4/2015 Duncan et al.
2015/0117842 A1 4/2015 Brammer et al.
2015/0122252 A1 5/2015 Frija
2015/0122274 A1 5/2015 Cohen et al.
2015/0122278 A1 5/2015 Hardgrove et al.
2015/0128965 A1 5/2015 Lord

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0128966 A1 5/2015 Lord
2015/0128967 A1 5/2015 Robinson et al.
2015/0128969 A1 5/2015 Chapman et al.
2015/0128970 A1 5/2015 Liu
2015/0128971 A1 5/2015 Verleur et al.
2015/0128972 A1 5/2015 Verleur et al.
2015/0128973 A1 5/2015 Li et al.
2015/0128976 A1 5/2015 Verleur et al.
2015/0128977 A1 5/2015 Li et al.
2015/0136153 A1 5/2015 Lord
2015/0136155 A1 5/2015 Verleur et al.
2015/0136156 A1 5/2015 Liu
2015/0136157 A1 5/2015 Liu
2015/0136158 A1 5/2015 Stevens et al.
2015/0142387 A1 5/2015 Alarcon et al.
2015/0144145 A1 5/2015 Chang et al.
2015/0144147 A1 5/2015 Li et al.
2015/0144148 A1 5/2015 Chen
2015/0150302 A1 6/2015 Metrangolo et al.
2015/0150303 A1 6/2015 Jensen
2015/0150305 A1 6/2015 Shenkal
2015/0150306 A1 6/2015 Chen
2015/0150307 A1 6/2015 Liu
2015/0150308 A1 6/2015 Monsees et al.
2015/0157053 A1 6/2015 Mayor
2015/0157054 A1 6/2015 Liu
2015/0157055 A1 6/2015 Lord
2015/0157056 A1 6/2015 Bowen et al.
2015/0163859 A1 6/2015 Schneider et al.
2015/0164138 A1 6/2015 Liu
2015/0164141 A1 6/2015 Newton
2015/0164142 A1 6/2015 Li et al.
2015/0164143 A1 6/2015 Maas
2015/0164144 A1 6/2015 Liu
2015/0164145 A1 6/2015 Zhou
2015/0164146 A1 6/2015 Li et al.
2015/0164147 A1 6/2015 Verleur et al.
2015/0167976 A1 6/2015 Recio
2015/0173124 A1 6/2015 Qiu
2015/0173417 A1 6/2015 Gennrich et al.
2015/0173419 A1 6/2015 Tu
2015/0173421 A1 6/2015 Hsieh
2015/0173422 A1 6/2015 Liu
2015/0181928 A1 7/2015 Liu
2015/0181937 A1 7/2015 Dubief et al.
2015/0181939 A1 7/2015 Liu
2015/0181940 A1 7/2015 Liu
2015/0181941 A1 7/2015 Liu
2015/0181943 A1 7/2015 Li et al.
2015/0181944 A1 7/2015 Li et al.
2015/0184846 A1 7/2015 Liu
2015/0186837 A1 7/2015 Bianco et al.
2015/0189695 A1 7/2015 Xiang
2015/0189915 A1 7/2015 Liu
2015/0189918 A1 7/2015 Liu
2015/0189919 A1 7/2015 Liu
2015/0189920 A1 7/2015 Liu
2015/0196055 A1 7/2015 Liu
2015/0196056 A1 7/2015 Liu
2015/0196057 A1 7/2015 Wu
2015/0196058 A1 7/2015 Lord
2015/0196059 A1 7/2015 Liu
2015/0196060 A1 7/2015 Wensley et al.
2015/0196062 A1 7/2015 Li et al.
2015/0200385 A1 7/2015 Liu
2015/0201674 A1 7/2015 Dooly et al.
2015/0201675 A1 7/2015 Lord
2015/0201676 A1 7/2015 Shin
2015/0208724 A1 7/2015 Wu
2015/0208725 A1 7/2015 Tsai
2015/0208726 A1 7/2015 Liu
2015/0208728 A1 7/2015 Lord
2015/0208729 A1 7/2015 Monsees et al.
2015/0208730 A1 7/2015 Li et al.
2015/0208731 A1 7/2015 Malamud et al.
2015/0216232 A1 8/2015 Bless et al.
2015/0216233 A1 8/2015 Sears et al.
2015/0216234 A1 8/2015 Chung
2015/0216235 A1 8/2015 Liu
2015/0216237 A1 8/2015 Wensley et al.
2015/0217067 A1 8/2015 Hearn et al.
2015/0217068 A1 8/2015 Wakalopulos
2015/0223520 A1 8/2015 Phillips et al.
2015/0223521 A1 8/2015 Menting et al.
2015/0223522 A1 8/2015 Ampolini et al.
2015/0223523 A1 8/2015 McCullough
2015/0224268 A1 8/2015 Henry et al.
2015/0227471 A1 8/2015 Stafford et al.
2015/0237914 A1 8/2015 Han
2015/0237917 A1 8/2015 Lord
2015/0237918 A1 8/2015 Liu
2015/0238723 A1 8/2015 Knudsen
2015/0245654 A1 9/2015 Memari et al.
2015/0245655 A1 9/2015 Memari et al.
2015/0245657 A1 9/2015 Memari et al.
2015/0245658 A1 9/2015 Worm et al.
2015/0245659 A1 9/2015 DePiano et al.
2015/0245660 A1 9/2015 Lord
2015/0245661 A1 9/2015 Milin
2015/0245665 A1 9/2015 Memari et al.
2015/0245666 A1 9/2015 Memari et al.
2015/0245667 A1 9/2015 Memari et al.
2015/0245668 A1 9/2015 Memari et al.
2015/0245669 A1 9/2015 Cadieux et al.
2015/0257441 A1 9/2015 Gerkin
2015/0257444 A1 9/2015 Chung
2015/0257445 A1 9/2015 Henry, Jr. et al.
2015/0257446 A1 9/2015 Chung
2015/0257447 A1 9/2015 Sullivan
2015/0257449 A1 9/2015 Gabbay
2015/0257451 A1 9/2015 Brannon et al.
2015/0258289 A1 9/2015 Henry, Jr. et al.
2015/0272211 A1 10/2015 Chung
2015/0272215 A1 10/2015 Esses
2015/0272217 A1 10/2015 Chen
2015/0272218 A1 10/2015 Chen
2015/0272220 A1 10/2015 Spinka et al.
2015/0272221 A1 10/2015 Liu
2015/0272222 A1 10/2015 Spinka et al.
2015/0272223 A1 10/2015 Weigensberg et al.
2015/0276262 A1 10/2015 Dai et al.
2015/0280273 A1 10/2015 Liu
2015/0282524 A1 10/2015 Elhalwani
2015/0282525 A1 10/2015 Plojoux et al.
2015/0282526 A1 10/2015 Wu
2015/0282527 A1 10/2015 Henry, Jr.
2015/0282529 A1 10/2015 Li et al.
2015/0282530 A1 10/2015 Johnson et al.
2015/0288468 A1 10/2015 Xiang
2015/0289565 A1 10/2015 Cadieux et al.
2015/0289567 A1 10/2015 Liu
2015/0295921 A1 10/2015 Cao
2015/0296883 A1 10/2015 Wu
2015/0296885 A1 10/2015 Liu
2015/0296886 A1 10/2015 Li et al.
2015/0296887 A1 10/2015 Zhu
2015/0296888 A1 10/2015 Liu
2015/0296889 A1 10/2015 Liu
2015/0304401 A1 10/2015 Liu
2015/0304402 A1 10/2015 Liu
2015/0305403 A1 10/2015 Coelho Belo Fernandes De Carvalho
2015/0305404 A1 10/2015 Rosales
2015/0305406 A1 10/2015 Li et al.
2015/0305407 A1 10/2015 Li et al.
2015/0305408 A1 10/2015 Liu
2015/0305409 A1 10/2015 Verleur et al.
2015/0305464 A1 10/2015 Nelson, Jr. et al.
2015/0313275 A1 11/2015 Anderson et al.
2015/0313282 A1 11/2015 Ademe et al.
2015/0313283 A1 11/2015 Collett et al.
2015/0313284 A1 11/2015 Liu
2015/0313285 A1 11/2015 Waller et al.
2015/0313287 A1 11/2015 Verleur et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2015/0313288 A1 11/2015 Liu
2015/0313868 A1 11/2015 Morgan
2015/0320114 A1 11/2015 Wu
2015/0320116 A1 11/2015 Bleloch et al.
2015/0322451 A1 11/2015 Kudithipudi et al.
2015/0327595 A1 11/2015 Scatterday
2015/0327596 A1 11/2015 Alarcon et al.
2015/0327597 A1 11/2015 Li et al.
2015/0327598 A1 11/2015 Xiang
2015/0328415 A1 11/2015 Minskoff et al.
2015/0332379 A1 11/2015 Alarcon
2015/0333542 A1 11/2015 Alarcon et al.
2015/0333552 A1 11/2015 Alarcon
2015/0333561 A1 11/2015 Alarcon
2015/0335071 A1 11/2015 Brinkley et al.
2015/0335072 A1 11/2015 Giller
2015/0335074 A1 11/2015 Leung
2015/0335075 A1 11/2015 Minskoff et al.
2015/0342254 A1 12/2015 Mironov et al.
2015/0342255 A1 12/2015 Wu
2015/0342256 A1 12/2015 Chen
2015/0342257 A1 12/2015 Chen
2015/0342258 A1 12/2015 Chen
2015/0342259 A1 12/2015 Baker et al.
2015/0351449 A1 12/2015 Righetti
2015/0351454 A1 12/2015 Huang
2015/0351455 A1 12/2015 Liu
2015/0351456 A1 12/2015 Johnson et al.
2015/0351457 A1 12/2015 Liu
2015/0357608 A1 12/2015 Huang
2015/0357839 A1 12/2015 Cai et al.
2015/0359258 A1 12/2015 Mishra et al.
2015/0359261 A1 12/2015 Li et al.
2015/0359262 A1 12/2015 Liu et al.
2015/0359263 A1 12/2015 Bellinger
2015/0359264 A1 12/2015 Fernando et al.
2015/0359265 A1 12/2015 Liu
2015/0366250 A1 12/2015 Landau
2015/0366265 A1 12/2015 Lansing
2015/0366266 A1 12/2015 Chen
2015/0366267 A1 12/2015 Liu
2015/0366268 A1 12/2015 Shabat
2015/0374035 A1 12/2015 Sanchez et al.
2015/0374039 A1 12/2015 Zhu
2015/0374040 A1 12/2015 Chen
2016/0000147 A1 1/2016 Li et al.
2016/0000148 A1 1/2016 Liu
2016/0000149 A1 1/2016 Scatterday
2016/0002649 A1 1/2016 Kudithipudi et al.
2016/0007650 A1 1/2016 Duncan et al.
2016/0007651 A1 1/2016 Ampolini et al.
2016/0007653 A1 1/2016 Tu
2016/0007654 A1 1/2016 Zhu
2016/0007655 A1 1/2016 Li et al.
2016/0010103 A1 1/2016 Kudithipudi et al.
2016/0015082 A1 1/2016 Liu
2016/0020048 A1 1/2016 Ware
2016/0021771 A1 1/2016 Zhang et al.
2016/0021930 A1 1/2016 Minskoff et al.
2016/0021931 A1 1/2016 Hawes et al.
2016/0021932 A1 1/2016 Silvestrini et al.
2016/0021933 A1 1/2016 Thorens et al.
2016/0021934 A1 1/2016 Cadieux et al.
2016/0029225 A1 1/2016 Hu
2016/0029694 A1 2/2016 Clements et al.
2016/0029697 A1 2/2016 Shafer
2016/0029698 A1 2/2016 Xiang
2016/0029699 A1 2/2016 Li et al.
2016/0029700 A1 2/2016 Li et al.
2016/0037826 A1 2/2016 Hearn et al.
2016/0044961 A1 2/2016 Liu
2016/0044964 A1 2/2016 Liu
2016/0044965 A1 2/2016 Liu
2016/0044966 A1 2/2016 Li et al.
2016/0044967 A1 2/2016 Bowen et al.
2016/0044968 A1 2/2016 Bowen et al.
2016/0049682 A1 2/2016 Won et al.
2016/0051716 A1 2/2016 Wheelock
2016/0053988 A1 2/2016 Quintana
2016/0057811 A1 2/2016 Alarcon et al.
2016/0058066 A1 3/2016 Banks et al.
2016/0058071 A1 3/2016 Hearn
2016/0058072 A1 3/2016 Liu
2016/0058073 A1 3/2016 Chen
2016/0058074 A1 3/2016 Liu
2016/0073677 A1 3/2016 Kappel et al.
2016/0073678 A1 3/2016 Fujisawa et al.
2016/0073690 A1 3/2016 Liu
2016/0073691 A1 3/2016 Liu
2016/0073692 A1 3/2016 Alarcon et al.
2016/0073693 A1 3/2016 Reevell
2016/0073694 A1 3/2016 Liu
2016/0080469 A1 3/2016 Liu
2016/0081393 A1 3/2016 Black
2016/0081394 A1 3/2016 Alarcon et al.
2016/0081395 A1 3/2016 Thorens et al.
2016/0088874 A1 3/2016 Lipowicz
2016/0089508 A1 3/2016 Smith et al.
2016/0091194 A1 3/2016 Liu
2016/0095352 A1 4/2016 Liu
2016/0095353 A1 4/2016 Liu
2016/0095354 A1 4/2016 Wu
2016/0095355 A1 4/2016 Hearn
2016/0095356 A1 4/2016 Chan
2016/0095357 A1 4/2016 Burton
2016/0099592 A1 4/2016 Gatta et al.
2016/0100456 A1 4/2016 Tsai
2016/0100632 A1 4/2016 Debono et al.
2016/0101909 A1 4/2016 Schennum et al.
2016/0106144 A1 4/2016 Muehlbauer et al.
2016/0106151 A1 4/2016 Swepston et al.
2016/0106152 A1 4/2016 Liu
2016/0106154 A1 4/2016 Lord
2016/0106155 A1 4/2016 Reevell
2016/0106156 A1 4/2016 Qiu
2016/0106936 A1 4/2016 Kimmel
2016/0109115 A1 4/2016 Lipowicz
2016/0113323 A1 4/2016 Liu
2016/0113325 A1 4/2016 Liu
2016/0113326 A1 4/2016 Li et al.
2016/0113327 A1 4/2016 Wu
2016/0120218 A1 5/2016 Schennum et al.
2016/0120220 A1 5/2016 Malgat et al.
2016/0120222 A1 5/2016 Bagai et al.
2016/0120223 A1 5/2016 Keen et al.
2016/0120224 A1 5/2016 Mishra et al.
2016/0120225 A1 5/2016 Mishra et al.
2016/0120226 A1 5/2016 Rado
2016/0120227 A1 5/2016 Levitz et al.
2016/0120228 A1 5/2016 Rostami et al.
2016/0121058 A1 5/2016 Chen
2016/0128384 A1 5/2016 Luciani et al.
2016/0128385 A1 5/2016 Lin
2016/0128387 A1 5/2016 Chen
2016/0128388 A1 5/2016 Liu
2016/0128389 A1 5/2016 Lamb et al.
2016/0128390 A1 5/2016 Liu
2016/0129205 A1 5/2016 Shahaf et al.
2016/0131629 A1 5/2016 Cadieux, Jr. et al.
2016/0132898 A1 5/2016 Cadieux et al.
2016/0134143 A1 5/2016 Liu
2016/0135494 A1 5/2016 Liu et al.
2016/0135500 A1 5/2016 Hearn et al.
2016/0135501 A1 5/2016 Liu
2016/0135503 A1 5/2016 Liu
2016/0135504 A1 5/2016 Li et al.
2016/0135505 A1 5/2016 Li et al.
2016/0135506 A1 5/2016 Sanchez et al.
2016/0135507 A1 5/2016 Thorens et al.
2016/0136153 A1 5/2016 Jenkins
2016/0136213 A1 5/2016 Paul
2016/0138795 A1 5/2016 Meinhart et al.
2016/0143354 A1 5/2016 Liu
2016/0143357 A1 5/2016 Liu

(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0143358 A1 5/2016 Zhu
2016/0143359 A1 5/2016 Xiang
2016/0143360 A1 5/2016 Sanchez et al.
2016/0143361 A1 5/2016 Juster et al.
2016/0143362 A1 5/2016 Boldrini
2016/0143363 A1 5/2016 Boldrini
2016/0143365 A1 5/2016 Liu
2016/0144458 A1 5/2016 Boldrini
2016/0150820 A1 6/2016 Liu
2016/0150821 A1 6/2016 Liu
2016/0150823 A1 6/2016 Liu
2016/0150824 A1 6/2016 Memari et al.
2016/0150826 A1 6/2016 Liu
2016/0150827 A1 6/2016 Liu
2016/0150828 A1 6/2016 Goldstein et al.
2016/0150872 A1 6/2016 Zayat
2016/0157523 A1 6/2016 Liu
2016/0157524 A1 6/2016 Bowen et al.
2016/0157525 A1 6/2016 Tucker et al.
2016/0158782 A1 6/2016 Henry, Jr. et al.
2016/0165952 A1 6/2016 Liu
2016/0165955 A1 6/2016 Home
2016/0166564 A1 6/2016 Myers et al.
2016/0167846 A1 6/2016 Zahr et al.
2016/0174076 A1 6/2016 Wu
2016/0174609 A1 6/2016 Mironov
2016/0174611 A1 6/2016 Monsees et al.
2016/0174613 A1 6/2016 Zuber et al.
2016/0176564 A1 6/2016 Garthaffner
2016/0177285 A1 6/2016 Voerman et al.
2016/0183592 A1 6/2016 Liu
2016/0183593 A1 6/2016 Liu
2016/0183594 A1 6/2016 Liu
2016/0183595 A1 6/2016 Grimandi et al.
2016/0183597 A1 6/2016 Li et al.
2016/0189216 A1 6/2016 Liu
2016/0192705 A1 7/2016 Borkovec et al.
2016/0192706 A1 7/2016 Kananen
2016/0192707 A1 7/2016 Li et al.
2016/0192708 A1 7/2016 Demeritt et al.
2016/0192709 A1 7/2016 Liu
2016/0192710 A1 7/2016 Liu
2016/0198759 A1 7/2016 Kuntawala et al.
2016/0198763 A1 7/2016 Adkins et al.
2016/0198765 A1 7/2016 Liu
2016/0198766 A1 7/2016 Liu
2016/0198767 A1 7/2016 Verleur
2016/0198768 A1 7/2016 Liu
2016/0198769 A1 7/2016 Liu
2016/0198770 A1 7/2016 Alarcon
2016/0200463 A1 7/2016 Hodges et al.
2016/0201224 A1 7/2016 Xiang
2016/0204637 A1 7/2016 Alarcon et al.
2016/0205998 A1 7/2016 Matsumoto et al.
2016/0205999 A1 7/2016 Liu
2016/0206000 A1 7/2016 Lord et al.
2016/0206002 A1 7/2016 Borkovec et al.
2016/0206005 A1 7/2016 Yamada et al.
2016/0206006 A1 7/2016 Li et al.
2016/0211693 A1 7/2016 Stevens et al.
2016/0212520 A1 7/2016 Merenda
2016/0213060 A1 7/2016 Thaler
2016/0213061 A1 7/2016 Liu
2016/0213062 A1 7/2016 Doyle
2016/0213065 A1 7/2016 Wensley et al.
2016/0213066 A1 7/2016 Zitzke et al.
2016/0213067 A1 7/2016 Hon
2016/0213866 A1 7/2016 Tan
2016/0219932 A1 8/2016 Glaser
2016/0219933 A1 8/2016 Henry, Jr. et al.
2016/0219934 A1 8/2016 Li et al.
2016/0219936 A1 8/2016 Alarcon
2016/0219937 A1 8/2016 Rado
2016/0219938 A1 8/2016 Mamoun et al.
2016/0221707 A1 8/2016 Xu et al.
2016/0226286 A1 8/2016 Xiang
2016/0227837 A1 8/2016 Hammel et al.
2016/0227838 A1 8/2016 Johnson et al.
2016/0227839 A1 8/2016 Zuber et al.
2016/0227840 A1 8/2016 Xiang
2016/0227841 A1 8/2016 Li et al.
2016/0227842 A1 8/2016 Xiang
2016/0233705 A1 8/2016 Liu
2016/0233708 A1 8/2016 Liu
2016/0235119 A1 8/2016 Liu
2016/0235120 A1 8/2016 Liu
2016/0235121 A1 8/2016 Rogan et al.
2016/0235124 A1 8/2016 Krietzman
2016/0235125 A1 8/2016 Safari
2016/0242463 A1 8/2016 Liu
2016/0242464 A1 8/2016 Liu
2016/0242465 A1 8/2016 Zheng et al.
2016/0242466 A1 8/2016 Lord et al.
2016/0242467 A1 8/2016 Vaughn
2016/0242468 A1 8/2016 Liu
2016/0249680 A1 9/2016 Liu
2016/0249682 A1 9/2016 Leadley et al.
2016/0249683 A1 9/2016 Li et al.
2016/0249684 A1 9/2016 Liu
2016/0255876 A1 9/2016 Rostami
2016/0255878 A1 9/2016 Huang et al.
2016/0260156 A1 9/2016 Liu
2016/0261021 A1 9/2016 Marion et al.
2016/0262443 A1 9/2016 Piccirilli et al.
2016/0262445 A1 9/2016 Benjak et al.
2016/0262449 A1 9/2016 Liu
2016/0262450 A1 9/2016 Liu
2016/0262451 A1 9/2016 Liu
2016/0262452 A1 9/2016 Zhu
2016/0262453 A1 9/2016 Ampolini et al.
2016/0262454 A1 9/2016 Sears et al.
2016/0262455 A1 9/2016 Chen
2016/0262456 A1 9/2016 Borkovec et al.
2016/0262457 A1 9/2016 Borkovec et al.
2016/0262459 A1 9/2016 Monsees et al.
2016/0262526 A1 9/2016 Gonzalez
2016/0268824 A1 9/2016 Liu
2016/0270441 A1 9/2016 Lewis et al.
2016/0270442 A1 9/2016 Liu
2016/0270443 A1 9/2016 Liu
2016/0270444 A1 9/2016 Lin
2016/0270445 A1 9/2016 Liu
2016/0270446 A1 9/2016 Shenkal et al.
2016/0270447 A1 9/2016 Borkovec
2016/0271347 A1 9/2016 Raichman
2016/0278163 A1 9/2016 Chen
2016/0278431 A1 9/2016 Liu
2016/0278432 A1 9/2016 Liu
2016/0278433 A1 9/2016 Xiang
2016/0278434 A1 9/2016 Liu
2016/0278435 A1 9/2016 Choukroun et al.
2016/0278436 A1 9/2016 Verleur et al.
2016/0280450 A1 9/2016 Hearn et al.
2016/0284197 A1 9/2016 Liu
2016/0285983 A1 9/2016 Liu
2016/0286856 A1 10/2016 Liu
2016/0286858 A1 10/2016 Liu
2016/0286859 A1 10/2016 Liu
2016/0286860 A1 10/2016 Flayler
2016/0286862 A1 10/2016 Silvetrini
2016/0286863 A1 10/2016 Lin
2016/0286864 A1 10/2016 Lin
2016/0286865 A1 10/2016 King et al.
2016/0295913 A1 10/2016 Guo et al.
2016/0295915 A1 10/2016 Jochnowitz et al.
2016/0295916 A1 10/2016 Malgat et al.
2016/0295917 A1 10/2016 Malgat et al.
2016/0295918 A1 10/2016 Liu
2016/0295920 A1 10/2016 Liu
2016/0295922 A1 10/2016 John et al.
2016/0295923 A1 10/2016 Lin
2016/0295924 A1 10/2016 Liu
2016/0295925 A1 10/2016 Chen
2016/0295926 A1 10/2016 Zuber

(56) **References Cited**

U.S. PATENT DOCUMENTS

2016/0297341 A1 10/2016 Wallace et al.
2016/0302471 A1 10/2016 Bowen et al.
2016/0302483 A1 10/2016 Liu
2016/0302484 A1 10/2016 Gupta et al.
2016/0302485 A1 10/2016 Alima
2016/0302486 A1 10/2016 Eroch
2016/0302487 A1 10/2016 Chen
2016/0302488 A1 10/2016 Fernando et al.
2016/0309775 A1 10/2016 Parker
2016/0309779 A1 10/2016 Liu
2016/0309780 A1 10/2016 Chen et al.
2016/0309781 A1 10/2016 Malgat et al.
2016/0309783 A1 10/2016 Hopps et al.
2016/0309784 A1 10/2016 Silvestrini et al.
2016/0309785 A1 10/2016 Holtz
2016/0309786 A1 10/2016 Holtz et al.
2016/0309789 A1 10/2016 Thomas, Jr.
2016/0315488 A1 10/2016 Moon
2016/0316818 A1 11/2016 Liu
2016/0316820 A1 11/2016 Liu
2016/0316821 A1 11/2016 Liu
2016/0316822 A1 11/2016 Liu
2016/0321879 A1 11/2016 Oh et al.
2016/0323404 A1 11/2016 Liu
2016/0324211 A1 11/2016 Yankelevich
2016/0324213 A1 11/2016 Liu
2016/0324215 A1 11/2016 Mironov et al.
2016/0324217 A1 11/2016 Cameron
2016/0324218 A1 11/2016 Wang et al.
2016/0324219 A1 11/2016 Li et al.
2016/0325055 A1 11/2016 Cameron
2016/0325858 A1 11/2016 Ampolini et al.
2016/0331022 A1 11/2016 Cameron
2016/0331023 A1 11/2016 Cameron
2016/0331024 A1 11/2016 Cameron
2016/0331025 A1 11/2016 Cameron
2016/0331026 A1 11/2016 Cameron
2016/0331027 A1 11/2016 Cameron
2016/0331028 A1 11/2016 Xu
2016/0331029 A1 11/2016 Contreras
2016/0331030 A1 11/2016 Ampolini et al.
2016/0331032 A1 11/2016 Malgat et al.
2016/0331033 A1 11/2016 Hopps et al.
2016/0331034 A1 11/2016 Cameron
2016/0331035 A1 11/2016 Cameron
2016/0331037 A1 11/2016 Cameron
2016/0331038 A1 11/2016 Farine et al.
2016/0331039 A1 11/2016 Thorens et al.
2016/0331040 A1 11/2016 Nakano et al.
2016/0332754 A1 11/2016 Brown et al.
2016/0334847 A1 11/2016 Cameron
2016/0337141 A1 11/2016 Cameron
2016/0337362 A1 11/2016 Cameron
2016/0337444 A1 11/2016 Cameron
2016/0338402 A1 11/2016 Buehler et al.
2016/0338405 A1 11/2016 Liu
2016/0338406 A1 11/2016 Liu
2016/0338407 A1 11/2016 Kerdemelidis
2016/0338408 A1 11/2016 Guenther, Jr. et al.
2016/0338409 A1 11/2016 Varone
2016/0338410 A1 11/2016 Batista et al.
2016/0338411 A1 11/2016 Liu
2016/0338412 A1 11/2016 Monsees et al.
2016/0338413 A1 11/2016 Li et al.
2016/0338945 A1 11/2016 Knight
2016/0345621 A1 12/2016 Li et al.
2016/0345625 A1 12/2016 Liu
2016/0345626 A1 12/2016 Wong et al.
2016/0345627 A1 12/2016 Liu
2016/0345628 A1 12/2016 Sabet
2016/0345630 A1 12/2016 Mironov et al.
2016/0345631 A1 12/2016 Monsees et al.
2016/0345632 A1 12/2016 Lipowicz
2016/0345633 A1 12/2016 DePiano et al.
2016/0345634 A1 12/2016 Fernando et al.
2016/0345636 A1 12/2016 Liu
2016/0351044 A1 12/2016 Liu
2016/0353798 A1 12/2016 Liu
2016/0353800 A1 12/2016 Di Carlo
2016/0353805 A1 12/2016 Hawes et al.
2016/0356751 A1 12/2016 Blackley
2016/0360784 A1 12/2016 Liu
2016/0360785 A1 12/2016 Bless et al.
2016/0360786 A1 12/2016 Bellinger et al.
2016/0360787 A1 12/2016 Bailey
2016/0360788 A1 12/2016 Wang
2016/0360789 A1 12/2016 Hawes et al.
2016/0360790 A1 12/2016 Calfee et al.
2016/0360792 A1 12/2016 Liu
2016/0360793 A1 12/2016 Liu
2016/0363570 A1 12/2016 Blackley
2016/0363917 A1 12/2016 Blackley
2016/0366725 A1 12/2016 Tucker et al.
2016/0366927 A1 12/2016 Liu
2016/0366928 A1 12/2016 Liu
2016/0366933 A1 12/2016 Liu
2016/0366935 A1 12/2016 Liu
2016/0366936 A1 12/2016 Liu
2016/0366937 A1 12/2016 Liu
2016/0366938 A1 12/2016 Wu
2016/0366939 A1 12/2016 Alarcon et al.
2016/0366940 A1 12/2016 Liu
2016/0366941 A1 12/2016 Lin
2016/0366942 A1 12/2016 Liu
2016/0366943 A1 12/2016 Li et al.
2016/0366945 A1 12/2016 Rado
2016/0366947 A1 12/2016 Monsees et al.
2016/0367925 A1 12/2016 Blackley
2016/0368670 A1 12/2016 Beardsall
2016/0368677 A1 12/2016 Parsons et al.
2016/0370335 A1 12/2016 Blackley
2016/0371437 A1 12/2016 Alarcon et al.
2016/0371464 A1 12/2016 Bricker
2016/0374390 A1 12/2016 Liu
2016/0374391 A1 12/2016 Liu
2016/0374392 A1 12/2016 Liu
2016/0374393 A1 12/2016 Chen
2016/0374394 A1 12/2016 Hawes et al.
2016/0374395 A1 12/2016 Jordan et al.
2016/0374396 A1 12/2016 Jordan et al.
2016/0374397 A1 12/2016 Jordan et al.
2016/0374398 A1 12/2016 Amir
2016/0374399 A1 12/2016 Monsees et al.
2016/0374400 A1 12/2016 Monsees et al.
2016/0374401 A1 12/2016 Liu
2017/0000190 A1 1/2017 Wu
2017/0000192 A1 1/2017 Li
2017/0006915 A1 1/2017 Li et al.
2017/0006916 A1 1/2017 Liu
2017/0006917 A1 1/2017 Alvarez
2017/0006918 A1 1/2017 Chen et al.
2017/0006919 A1 1/2017 Liu
2017/0006920 A1 1/2017 Liu
2017/0006921 A1 1/2017 Lemay et al.
2017/0006922 A1 1/2017 Wang et al.
2017/0013875 A1 1/2017 Schennum et al.
2017/0013876 A1 1/2017 Schennum et al.
2017/0013878 A1 1/2017 Schuler et al.
2017/0013880 A1 1/2017 O'Brien et al.
2017/0013881 A1 1/2017 Liu
2017/0013882 A1 1/2017 Liu
2017/0013883 A1 1/2017 Han et al.
2017/0013885 A1 1/2017 Qiu
2017/0014582 A1 1/2017 Skoda
2017/0018000 A1 1/2017 Cameron
2017/0019951 A1 1/2017 Louveau et al.
2017/0020188 A1 1/2017 Cameron
2017/0020191 A1 1/2017 Lamb et al.
2017/0020193 A1 1/2017 Davis et al.
2017/0020194 A1 1/2017 Rehders
2017/0020195 A1 1/2017 Cameron
2017/0020196 A1 1/2017 Cameron
2017/0020197 A1 1/2017 Cameron
2017/0020198 A1 1/2017 Naqwi et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0020201 A1 1/2017 Xiang
2017/0020791 A1 1/2017 Moszner et al.
2017/0021969 A1 1/2017 Smith et al.
2017/0023952 A1 1/2017 Henry, Jr. et al.
2017/0027221 A1 2/2017 Liu
2017/0027223 A1 2/2017 Eksouzian
2017/0027224 A1 2/2017 Volodarsky
2017/0027227 A1 2/2017 Lipowicz
2017/0027228 A1 2/2017 Rastogi
2017/0027229 A1 2/2017 Cameron
2017/0027230 A1 2/2017 Fornarelli
2017/0027231 A1 2/2017 Xiang
2017/0027232 A1 2/2017 Scheck et al.
2017/0027233 A1 2/2017 Mironov
2017/0027234 A1 2/2017 Farine et al.
2017/0033568 A1 2/2017 Holzherr
2017/0033836 A1 2/2017 Bernauer et al.
2017/0035101 A1 2/2017 Balder
2017/0035109 A1 2/2017 Liu
2017/0035110 A1 2/2017 Keen
2017/0035111 A1 2/2017 Slurink et al.
2017/0035112 A1 2/2017 Thorens
2017/0035113 A1 2/2017 Thorens
2017/0035114 A1 2/2017 Lord
2017/0035115 A1 2/2017 Monsees et al.
2017/0035117 A1 2/2017 Lin
2017/0035118 A1 2/2017 Liu
2017/0035119 A1 2/2017 Otto
2017/0041646 A1 2/2017 Pizzurro et al.
2017/0042225 A1 2/2017 Liu
2017/0042227 A1 2/2017 Gavrielov et al.
2017/0042228 A1 2/2017 Liu
2017/0042229 A1 2/2017 Liu
2017/0042230 A1 2/2017 Cameron
2017/0042231 A1 2/2017 Cameron
2017/0042242 A1 2/2017 Hon
2017/0042243 A1 2/2017 Plojoux et al.
2017/0042245 A1 2/2017 Buchberger et al.
2017/0042246 A1 2/2017 Lau et al.
2017/0042247 A1 2/2017 Xiang
2017/0042248 A1 2/2017 Xiang
2017/0042250 A1 2/2017 Takeuchi et al.
2017/0046357 A1 2/2017 Cameron
2017/0046722 A1 2/2017 Ertugrul
2017/0046738 A1 2/2017 Cameron
2017/0047756 A1 2/2017 Xiang
2017/0048691 A1 2/2017 Liu
2017/0049149 A1 2/2017 Carty
2017/0049150 A1 2/2017 Xue et al.
2017/0049151 A1 2/2017 Xue et al.
2017/0049152 A1 2/2017 Liu
2017/0049153 A1 2/2017 Guo et al.
2017/0049154 A1 2/2017 Batista
2017/0049155 A1 2/2017 Liu
2017/0049156 A1 2/2017 Wang et al.
2017/0050798 A1 2/2017 Ludewig et al.
2017/0055577 A1 3/2017 Batista
2017/0055579 A1 3/2017 Kuna et al.
2017/0055586 A1 3/2017 Liu
2017/0055588 A1 3/2017 Cameron
2017/0055589 A1 3/2017 Fernando et al.
2017/0064994 A1 3/2017 Xu et al.
2017/0064999 A1 3/2017 Perez et al.
2017/0065000 A1 3/2017 Sears et al.
2017/0065001 A1 3/2017 Li et al.
2017/0066556 A1 3/2017 Liu
2017/0071249 A1 3/2017 Ampolini et al.
2017/0071251 A1 3/2017 Goch
2017/0071252 A1 3/2017 Liu
2017/0071256 A1 3/2017 Verleur et al.
2017/0071257 A1 3/2017 Lin
2017/0071258 A1 3/2017 Li et al.
2017/0071260 A1 3/2017 Li et al.
2017/0071262 A1 3/2017 Liu
2017/0079110 A1 3/2017 Plattner
2017/0079319 A1 3/2017 Muhammed et al.
2017/0079321 A1 3/2017 Golz
2017/0079322 A1 3/2017 Li et al.
2017/0079323 A1 3/2017 Wang
2017/0079324 A1 3/2017 Eksouzian
2017/0079327 A1 3/2017 Wu et al.
2017/0079328 A1 3/2017 Wu
2017/0079329 A1 3/2017 Zitzke
2017/0079330 A1 3/2017 Mironov et al.
2017/0079331 A1 3/2017 Monsees et al.
2017/0079332 A1 3/2017 Li et al.
2017/0086496 A1 3/2017 Cameron
2017/0086497 A1 3/2017 Cameron
2017/0086498 A1 3/2017 Daryani
2017/0086499 A1 3/2017 Mize
2017/0086500 A1 3/2017 Li et al.
2017/0086501 A1 3/2017 Buehler et al.
2017/0086502 A1 3/2017 Hearn et al.
2017/0086503 A1 3/2017 Cameron
2017/0086504 A1 3/2017 Cameron
2017/0086505 A1 3/2017 Cameron
2017/0086506 A1 3/2017 Rado
2017/0086507 A1 3/2017 Rado
2017/0086508 A1 3/2017 Mironov et al.
2017/0091490 A1 3/2017 Cameron
2017/0091853 A1 3/2017 Cameron
2017/0092106 A1 3/2017 Cameron
2017/0092900 A1 3/2017 Yang
2017/0093960 A1 3/2017 Cameron
2017/0093981 A1 3/2017 Cameron
2017/0094998 A1 4/2017 Bernauer et al.
2017/0094999 A1 4/2017 Hearn et al.
2017/0095000 A1 4/2017 Spirito et al.
2017/0095001 A1 4/2017 Liu
2017/0095002 A1 4/2017 Silvestrini
2017/0095003 A1 4/2017 Mironov
2017/0095004 A1 4/2017 Liu
2017/0095005 A1 4/2017 Monsees et al.
2017/0095518 A1 4/2017 Bjorncrantz
2017/0095623 A1 4/2017 Trzecieski
2017/0099877 A1 4/2017 Worm et al.
2017/0099879 A1 4/2017 Heidl
2017/0099880 A1 4/2017 Hawes
2017/0101256 A1 4/2017 Zeitlin et al.
2017/0102013 A1 4/2017 Wallman et al.
2017/0105448 A1 4/2017 Scarpulla
2017/0105449 A1 4/2017 Hearn et al.
2017/0105450 A1 4/2017 Reed et al.
2017/0105451 A1 4/2017 Fornarelli
2017/0105452 A1 4/2017 Mironov et al.
2017/0105453 A1 4/2017 Li et al.
2017/0105454 A1 4/2017 Li et al.
2017/0105455 A1 4/2017 Qiu
2017/0108210 A1 4/2017 Meinhart et al.
2017/0108840 A1 4/2017 Hawes et al.
2017/0109877 A1 4/2017 Peleg et al.
2017/0112182 A1 4/2017 Arnold
2017/0112190 A1 4/2017 Buchberger
2017/0112192 A1 4/2017 Shan
2017/0112193 A1 4/2017 Chen
2017/0112196 A1 4/2017 Sur et al.
2017/0112197 A1 4/2017 Li et al.
2017/0113819 A1 4/2017 Marz
2017/0117654 A1 4/2017 Cruz
2017/0118292 A1 4/2017 Xiang
2017/0118584 A1 4/2017 Xiang
2017/0119040 A1 5/2017 Cameron
2017/0119044 A1 5/2017 Oligschlaeger et al.
2017/0119050 A1 5/2017 Blandino et al.
2017/0119052 A1 5/2017 Williams et al.
2017/0119053 A1 5/2017 Henry, Jr. et al.
2017/0119054 A1 5/2017 Zinovik et al.
2017/0119055 A1 5/2017 Liu
2017/0119057 A1 5/2017 Liu
2017/0119058 A1 5/2017 Cameron
2017/0119060 A1 5/2017 Li et al.
2017/0119061 A1 5/2017 Li et al.
2017/0127722 A1 5/2017 Davis et al.
2017/0127723 A1 5/2017 Wu

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0127724 A1 5/2017 Liu
2017/0127725 A1 5/2017 Buchberger et al.
2017/0127726 A1 5/2017 Xiang
2017/0127728 A1 5/2017 Li et al.
2017/0129661 A1 5/2017 Van Tassell, III et al.
2017/0135397 A1 5/2017 Buehler et al.
2017/0135398 A1 5/2017 Scott et al.
2017/0135399 A1 5/2017 Gavrielov et al.
2017/0135400 A1 5/2017 Liu
2017/0135401 A1 5/2017 Dickens
2017/0135402 A1 5/2017 Zitzke
2017/0135403 A1 5/2017 Liu
2017/0135407 A1 5/2017 Cameron
2017/0135408 A1 5/2017 Cameron
2017/0135409 A1 5/2017 Cameron
2017/0135410 A1 5/2017 Cameron
2017/0135411 A1 5/2017 Cameron
2017/0135412 A1 5/2017 Cameron
2017/0136193 A1 5/2017 Cameron
2017/0136194 A1 5/2017 Cameron
2017/0136301 A1 5/2017 Cameron
2017/0143035 A1 5/2017 Pucci
2017/0143037 A9 5/2017 Larson
2017/0143038 A1 5/2017 Dickens
2017/0143040 A1 5/2017 Liu
2017/0143043 A1 5/2017 Liu
2017/0143917 A1 5/2017 Cohen et al.
2017/0144827 A1 5/2017 Batista
2017/0146005 A1 5/2017 Edelen
2017/0150753 A1 6/2017 Macko
2017/0150754 A1 6/2017 Lin
2017/0150755 A1 6/2017 Batista
2017/0150756 A1 6/2017 Rexroad et al.
2017/0150758 A1 6/2017 Fernando et al.
2017/0156397 A1 6/2017 Sur et al.
2017/0156398 A1 6/2017 Sur et al.
2017/0156400 A1 6/2017 Liu
2017/0156401 A1 6/2017 Liu
2017/0156402 A1 6/2017 Liu
2017/0156403 A1 6/2017 Gill et al.
2017/0156404 A1 6/2017 Novak, III et al.
2017/0156408 A1 6/2017 Li et al.
2017/0158436 A1 6/2017 Slurink
2017/0162523 A1 6/2017 Hu
2017/0162979 A1 6/2017 Liu
2017/0164655 A1 6/2017 Chen
2017/0164656 A1 6/2017 Eusepi et al.
2017/0164657 A1 6/2017 Batista
2017/0164658 A1 6/2017 Lin et al.
2017/0170439 A1 6/2017 Jarvis et al.
2017/0172204 A1 6/2017 Kane et al.
2017/0172205 A1 6/2017 Chang et al.
2017/0172207 A1 6/2017 Liu
2017/0172208 A1 6/2017 Mironov
2017/0172209 A1 6/2017 Saydar et al.
2017/0172213 A1 6/2017 Hon
2017/0172214 A1 6/2017 Li et al.
2017/0172215 A1 6/2017 Li et al.
2017/0181223 A1 6/2017 Sur et al.
2017/0181467 A1 6/2017 Cameron
2017/0181468 A1 6/2017 Bowen et al.
2017/0181470 A1 6/2017 Li
2017/0181471 A1 6/2017 Phillips et al.
2017/0181473 A1 6/2017 Batista et al.
2017/0181474 A1 6/2017 Cameron
2017/0181475 A1 6/2017 Cameron
2017/0181476 A1 6/2017 Li et al.
2017/0181928 A1 6/2017 Collins et al.
2017/0185364 A1 6/2017 Cameron
2017/0186122 A1 6/2017 Levings et al.
2017/0188626 A1 7/2017 Davis et al.
2017/0188627 A1 7/2017 Sur
2017/0188628 A1 7/2017 Montgomery
2017/0188629 A1 7/2017 Dickens et al.
2017/0188631 A1 7/2017 Lin
2017/0188632 A1 7/2017 Hon
2017/0188634 A1 7/2017 Plojoux et al.
2017/0188635 A1 7/2017 Force et al.
2017/0188636 A1 7/2017 Li et al.
2017/0196263 A1 7/2017 Sur
2017/0196264 A1 7/2017 Liu
2017/0196265 A1 7/2017 Liu
2017/0196267 A1 7/2017 Zou et al.
2017/0196268 A1 7/2017 Reevell
2017/0196269 A1 7/2017 Bernauer et al.
2017/0196270 A1 7/2017 Vick et al.
2017/0196271 A1 7/2017 Levitz et al.
2017/0196272 A1 7/2017 Li et al.
2017/0196273 A1 7/2017 Qiu
2017/0202265 A1 7/2017 Hawes et al.
2017/0202266 A1 7/2017 Sur
2017/0202267 A1 7/2017 Liu
2017/0202268 A1 7/2017 Li et al.
2017/0207499 A1 7/2017 Leadley
2017/0208857 A1 7/2017 Branton et al.
2017/0208858 A1 7/2017 Li
2017/0208862 A1 7/2017 Li et al.
2017/0208863 A1 7/2017 Davis et al.
2017/0208864 A1 7/2017 Anderson, Jr. et al.
2017/0208865 A1 7/2017 Nettenstrom et al.
2017/0208866 A1 7/2017 Liu
2017/0208867 A1 7/2017 Li et al.
2017/0208868 A1 7/2017 Li et al.
2017/0208869 A1 7/2017 Li et al.
2017/0208870 A1 7/2017 Liu
2017/0208882 A1 7/2017 Lambertz
2017/0214261 A1 7/2017 Gratton
2017/0215470 A1 8/2017 Piccirilli et al.
2017/0215473 A1 8/2017 Nakano et al.
2017/0215474 A1 8/2017 Li
2017/0215476 A1 8/2017 Dickens et al.
2017/0215477 A1 8/2017 Reevell
2017/0215478 A1 8/2017 Harrison et al.
2017/0215479 A1 8/2017 Kies
2017/0215480 A1 8/2017 Qiu
2017/0215481 A1 8/2017 Li et al.
2017/0215482 A1 8/2017 Levitz et al.
2017/0215483 A1 8/2017 Li et al.
2017/0215484 A1 8/2017 Xiang
2017/0215485 A1 8/2017 Zitzke
2017/0217607 A1 8/2017 Slurink
2017/0219199 A1 8/2017 Lou et al.
2017/0219391 A1 8/2017 Lin et al.
2017/0222468 A1 8/2017 Schennum et al.
2017/0224013 A1 8/2017 Huang
2017/0224014 A1 8/2017 Fraser
2017/0224016 A1 8/2017 Reevell
2017/0224017 A1 8/2017 Li et al.
2017/0224018 A1 8/2017 Li et al.
2017/0224022 A1 8/2017 Liu
2017/0224023 A1 8/2017 Lin et al.
2017/0224024 A1 8/2017 Jochnowitz et al.
2017/0229885 A1 8/2017 Bernauer
2017/0229888 A1 8/2017 Liu
2017/0231266 A1 8/2017 Mishra et al.
2017/0231267 A1 8/2017 Shi et al.
2017/0231269 A1 8/2017 Besso et al.
2017/0231273 A1 8/2017 Xiang
2017/0231275 A1 8/2017 Guenther
2017/0231276 A1 8/2017 Mironov et al.
2017/0231277 A1 8/2017 Mironov et al.
2017/0231278 A1 8/2017 Mironov et al.
2017/0231279 A1 8/2017 Watson
2017/0231280 A1 8/2017 Anton
2017/0231281 A1 8/2017 Hatton et al.
2017/0231282 A1 8/2017 Bowen et al.
2017/0231283 A1 8/2017 Gadas
2017/0231284 A1 8/2017 Newns
2017/0231285 A1 8/2017 Holzherr et al.
2017/0231286 A1 8/2017 Borkovec et al.
2017/0233114 A1 8/2017 Christensen et al.
2017/0238596 A1 8/2017 Matsumoto et al.
2017/0238605 A1 8/2017 Matsumoto et al.
2017/0238606 A1 8/2017 Matsumoto et al.

(56) **References Cited**

U.S. PATENT DOCUMENTS

2017/0238608 A1 8/2017 Matsumoto et al.
2017/0238609 A1 8/2017 Schlipf
2017/0238611 A1 8/2017 Buchberger
2017/0238612 A1 8/2017 Daryani et al.
2017/0238613 A1 8/2017 Suess et al.
2017/0238614 A1 8/2017 Li et al.
2017/0238617 A1 8/2017 Scatterday
2017/0241857 A1 8/2017 Hearn et al.
2017/0245543 A1 8/2017 Karles et al.
2017/0245546 A1 8/2017 Huang
2017/0245547 A1 8/2017 Lipowicz
2017/0245550 A1 8/2017 Freelander
2017/0245551 A1 8/2017 Reevell
2017/0245554 A1 8/2017 Perez et al.
2017/0246399 A1 8/2017 Forlani et al.
2017/0246405 A1 8/2017 Wensley et al.
2017/0246407 A1 8/2017 Matsumoto et al.
2017/0250552 A1 8/2017 Liu
2017/0251714 A1 9/2017 Mishra et al.
2017/0251718 A1 9/2017 Armoush et al.
2017/0251719 A1 9/2017 Cyphert et al.
2017/0251721 A1 9/2017 Rostami et al.
2017/0251722 A1 9/2017 Kobal et al.
2017/0251723 A1 9/2017 Kobal et al.
2017/0251724 A1 9/2017 Lamb et al.
2017/0251725 A1 9/2017 Buchberger et al.
2017/0251726 A1 9/2017 Nielsen
2017/0251727 A1 9/2017 Nielsen
2017/0251728 A1 9/2017 Peleg et al.
2017/0251729 A1 9/2017 Li et al.
2017/0258129 A1 9/2017 Haun
2017/0258132 A1 9/2017 Rostami et al.
2017/0258134 A1 9/2017 Kane
2017/0258137 A1 9/2017 Smith et al.
2017/0258138 A1 9/2017 Rostami et al.
2017/0258139 A1 9/2017 Rostami et al.
2017/0258140 A1 9/2017 Rostami et al.
2017/0258142 A1 9/2017 Hatton et al.
2017/0258143 A1 9/2017 Lederer
2017/0259170 A1 9/2017 Bowen et al.
2017/0259954 A1 9/2017 Schwester
2017/0261200 A1 9/2017 Stultz
2017/0265517 A1 9/2017 Swede et al.
2017/0265522 A1 9/2017 Li et al.
2017/0265524 A1 9/2017 Cadieux et al.
2017/0265525 A1 9/2017 Li et al.
2017/0266397 A1 9/2017 Mayle et al.
2017/0273353 A1 9/2017 Gindrat
2017/0273354 A1 9/2017 Tucker et al.
2017/0273355 A1 9/2017 Rogers et al.
2017/0273357 A1 9/2017 Barbuck
2017/0273358 A1 9/2017 Batista et al.
2017/0273359 A1 9/2017 Liu
2017/0273360 A1 9/2017 Brinkley et al.
2017/0273361 A1 9/2017 Li et al.
2017/0273914 A1 9/2017 Knudsen
2017/0280767 A1 10/2017 Li et al.
2017/0280768 A1 10/2017 Lipowicz
2017/0280769 A1 10/2017 Li et al.
2017/0280770 A1 10/2017 Wang et al.
2017/0280771 A1 10/2017 Courbat et al.
2017/0280775 A1 10/2017 Manca et al.
2017/0280776 A1 10/2017 Manca et al.
2017/0280778 A1 10/2017 Force
2017/0281883 A1 10/2017 Li et al.
2017/0283154 A1 10/2017 Karles et al.
2017/0285810 A1 10/2017 Krah
2017/0290368 A1 10/2017 Hearn
2017/0290369 A1 10/2017 Norasak
2017/0290370 A1 10/2017 Garthaffner et al.
2017/0290371 A1 10/2017 Davis et al.
2017/0290373 A1 10/2017 Hon
2017/0290998 A1 10/2017 Poston et al.
2017/0295840 A1 10/2017 Rath et al.
2017/0295843 A1 10/2017 Storch
2017/0295844 A1 10/2017 Thevenaz et al.
2017/0295845 A1 10/2017 Bajpai et al.
2017/0295846 A1 10/2017 Liu
2017/0295847 A1 10/2017 Liu
2017/0295848 A1 10/2017 LaMothe
2017/0295849 A1 10/2017 Cadieux et al.
2017/0297892 A1 10/2017 Li et al.
2017/0301898 A1 10/2017 Lin et al.
2017/0302089 A1 10/2017 Bernauer et al.
2017/0302324 A1 10/2017 Stanimirovic et al.
2017/0303597 A1 10/2017 Tsui
2017/0311648 A1 11/2017 Gill et al.
2017/0318860 A1 11/2017 Adair
2017/0318861 A1 11/2017 Thorens
2017/0325503 A1 11/2017 Liu
2017/0325504 A1 11/2017 Liu
2017/0325506 A1 11/2017 Batista
2017/0332695 A1 11/2017 Zappoli et al.
2017/0333415 A1 11/2017 Williams
2017/0333650 A1 11/2017 Buchberger et al.
2017/0333651 A1 11/2017 Qiu
2017/0334605 A1 11/2017 Murphy et al.
2017/0367406 A1 12/2017 Schuler et al.

FOREIGN PATENT DOCUMENTS

AU 2017202891 A1 5/2017
CA 2641869 A1 5/2010
CN 1122213 A 5/1996
CN 201018481 Y 2/2008
CN 201430916 Y 3/2010
CN 101869356 A 10/2010
CN 301547686 S 5/2011
CN 301970169 S 6/2012
CN 102754924 A 10/2012
CN 302396126 S 4/2013
CN 103141944 A 6/2013
CN 302799554 S 4/2014
CN 302810246 S 4/2014
CN 302884434 S 8/2014
CN 302926289 S 8/2014
CN 302950830 S 9/2014
CN 303089422 S 1/2015
CN 303091331 S 1/2015
CN 303210086 S 5/2015
CN 303103389 S 11/2015
CN 303568163 S 1/2016
CN 303103390 S 2/2016
DE 19854005 A1 5/2000
DE 19854012 A1 5/2000
EP 0283672 A2 9/1988
EP 0503767 A1 9/1992
EP 0532194 A1 3/1993
EP 0535695 A2 4/1993
EP 0762258 A2 3/1997
EP 2110033 A1 10/2009
EP 2186507 A2 5/2010
EP 2399636 A1 12/2011
EP 2573900 A1 3/2013
EP 2614731 A1 7/2013
EP 2711006 A1 3/2014
EP 2641669 B1 5/2014
EP 2789248 A1 10/2014
EP 2493342 B1 12/2014
EP 2856893 A1 4/2015
EP 2862454 A1 4/2015
EP 2862457 A1 4/2015
EP 2944206 A1 11/2015
EP 2952110 A1 12/2015
EP 2989912 A1 3/2016
EP 3001918 A1 4/2016
EP 3007305 A1 4/2016
EP 3012213 A1 4/2016
EP 3016233 A1 5/2016
EP 3023016 A1 5/2016
EP 3023351 A1 5/2016
EP 3023947 A1 5/2016
EP 3025598 A1 6/2016
EP 3026779 A1 6/2016

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

EP	3031338	A1	6/2016
EP	3047742	A1	7/2016
EP	3056099	A1	8/2016
EP	3061358	A1	8/2016
EP	3075270	A1	10/2016
EP	3075271	A1	10/2016
EP	3081102	A1	10/2016
EP	3085638	A1	10/2016
EP	3087853	A1	11/2016
EP	3097803	A1	11/2016
EP	3103355	A1	12/2016
EP	3103356	A1	12/2016
EP	3111787	A1	1/2017
EP	3130238	A1	2/2017
EP	3132843	A1	2/2017
EP	3135139	A1	3/2017
EP	3135603	A1	3/2017
EP	3143882	A3	3/2017
EP	3143884	A3	4/2017
EP	3155908	A1	4/2017
EP	3158880	A1	4/2017
EP	3158881	A1	4/2017
EP	3195738	A2	7/2017
EP	3165102	A3	8/2017
EP	3199043	A1	8/2017
EP	3205220	A1	8/2017
EP	3205597	A1	8/2017
EP	3213649	A1	9/2017
EP	3225118	A1	10/2017
EP	3228198	A1	10/2017
EP	3228345	A1	10/2017
ES	2118034	A1	9/1998
FR	002626416-001		4/2015
FR	002626416-002		4/2015
GB	1025630	A	4/1966
GB	1065678	A	4/1967
GB	2533174	A	6/2016
IE	S20050615		9/2005
JP	62278975		12/1987
JP	H06114105	A	4/1994
JP	09-075058		3/1997
JP	H09075058	A	3/1997
JP	11178563		6/1999
JP	2000203639	A	7/2000
JP	2000236865	A	9/2000
JP	2001161819	A	6/2001
JP	2001165437	A	6/2001
JP	2006320285	A	11/2006
JP	2006320286	A	11/2006
JP	2009213428	A	9/2009
JP	2010020929	A	1/2010
JP	2011024430	A	2/2011
JP	2012005412	A	1/2012
JP	2015504669	A	2/2015
JP	201712730	A	1/2017
TW	201436722	A	10/2014
TW	201438608	A	10/2014
TW	201524383	A	7/2015
WO	WO-9712639	A1	4/1997
WO	WO-2000005976	A1	2/2000
WO	WO-0028842	A1	5/2000
WO	WO-03055486	A1	7/2003
WO	WO-03056948	A1	7/2003
WO	WO-03082031	A1	10/2003
WO	WO-03101454	A1	12/2003
WO	WO-2004064548	A1	8/2004
WO	WO-2004080216	A1	9/2004
WO	WO-2005020726	A1	3/2005
WO	WO-2005060366	A2	7/2005
WO	WO-2006021153	A1	3/2006
WO	WO-2007066374	A1	6/2007
WO	WO-2007078273	A1	7/2007
WO	WO-2007095109	A2	8/2007
WO	WO-2007117675	A2	10/2007
WO	WO-2007/141520	A1	12/2007
WO	WO-2008077271	A1	7/2008
WO	WO-2008151777	A2	12/2008
WO	WO-2009003204	A2	1/2009
WO	WO-2010003480	A1	1/2010
WO	WO-2010118122	A1	10/2010
WO	WO-2010118644	A1	10/2010
WO	WO-2010140841	A2	12/2010
WO	WO-2010145805	A1	12/2010
WO	WO-2011010334	A1	1/2011
WO	WO-2011050964	A1	5/2011
WO	WO-2011125058	A1	10/2011
WO	WO-2012019533	A1	2/2012
WO	WO-2012043941	A1	4/2012
WO	WO-2012062600	A1	5/2012
WO	WO-2012088675	A1	7/2012
WO	WO-2012091249	A1	7/2012
WO	WO-2012100523	A1	8/2012
WO	WO-2012129812	A1	10/2012
WO	WO-2012134117	A2	10/2012
WO	WO-2012164033	A1	12/2012
WO	WO-2012173322	A1	12/2012
WO	WO-2012174677	A1	12/2012
WO	WO-D079112-0010		12/2012
WO	WO-2013012157	A1	1/2013
WO	WO-2013020220	A1	2/2013
WO	WO-2013030202	A1	3/2013
WO	WO-2013034453	A1	3/2013
WO	WO-2013040193	A2	3/2013
WO	WO-2013044537	A1	4/2013
WO	WO-2013076750	A1	5/2013
WO	WO-2013083635	A1	6/2013
WO	WO-2013089551	A1	6/2013
WO	WO-2013110208	A1	8/2013
WO	WO-2013110209	A1	8/2013
WO	WO-2013110210	A1	8/2013
WO	WO-2013113173	A1	8/2013
WO	WO-2013113174	A1	8/2013
WO	WO-2013113612	A1	8/2013
WO	WO-2013116983	A1	8/2013
WO	WO-2013131763	A1	9/2013
WO	WO-2013142678	A1	9/2013
WO	WO-2013150406	A2	10/2013
WO	WO-2013156658	A1	10/2013
WO	WO-2013165878	A1	11/2013
WO	WO-2013171206	A1	11/2013
WO	WO-2013174001	A1	11/2013
WO	WO-2014020539	A1	2/2014
WO	WO-2014020953	A1	2/2014
WO	WO-2014023171	A1	2/2014
WO	WO-2014032280	A1	3/2014
WO	WO-2014040915	A1	3/2014
WO	WO-2014047948	A1	4/2014
WO	WO-2014047955	A1	4/2014
WO	WO-2014067236	A1	5/2014
WO	WO-2014071747	A1	5/2014
WO	WO-2014101119	A1	7/2014
WO	WO-2014101401	A1	7/2014
WO	WO-2014101734	A1	7/2014
WO	WO-2014106323	A1	7/2014
WO	WO-2014110761	A1	7/2014
WO	WO-2014113949	A1	7/2014
WO	WO-2014117382	A1	8/2014
WO	WO-2014121509	A1	8/2014
WO	WO-2014125340	A1	8/2014
WO	WO-2014127446	A1	8/2014
WO	WO-2014134781	A1	9/2014
WO	WO-2014144678	A2	9/2014
WO	WO-2014146270	A1	9/2014
WO	WO-2014147470	A2	9/2014
WO	WO-2014161181	A1	10/2014
WO	WO-2014166039	A1	10/2014
WO	WO-2014167530	A1	10/2014
WO	WO-2014169437	A1	10/2014
WO	WO-2014169667	A1	10/2014
WO	WO-2014185937	A1	11/2014
WO	WO-2014186983	A1	11/2014
WO	WO-2014194499	A1	12/2014
WO	WO-2014195687	A1	12/2014
WO	WO-2014198042	A1	12/2014

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2014201610	A1	12/2014
WO	WO-2014201611	A1	12/2014
WO	WO-2014201646	A1	12/2014
WO	WO-2014201664	A1	12/2014
WO	WO-2014201666	A1	12/2014
WO	WO-2014201668	A1	12/2014
WO	WO-2014205749	A1	12/2014
WO	WO-2014205780	A1	12/2014
WO	WO-2014205807	A1	12/2014
WO	WO-2014205811	A1	12/2014
WO	WO-2014206148	A1	12/2014
WO	WO-2015000125	A1	1/2015
WO	WO-2015000180	A1	1/2015
WO	WO-2015003327	A1	1/2015
WO	WO-2015003372	A1	1/2015
WO	WO-2015003374	A1	1/2015
WO	WO-2015006929	A1	1/2015
WO	WO-2015010242	A1	1/2015
WO	WO-2015010277	A1	1/2015
WO	WO-2015010284	A1	1/2015
WO	WO-2015010291	A1	1/2015
WO	WO-2015010310	A1	1/2015
WO	WO-2015010336	A1	1/2015
WO	WO-2015010345	A1	1/2015
WO	WO-2015010349	A1	1/2015
WO	WO-2015013890	A1	2/2015
WO	WO-2015013891	A1	2/2015
WO	WO-2015013892	A1	2/2015
WO	WO-2015013926	A1	2/2015
WO	WO-2015013950	A1	2/2015
WO	WO-2015013967	A1	2/2015
WO	WO-2015015156	A1	2/2015
WO	WO-2015017971	A1	2/2015
WO	WO-2015018026	A1	2/2015
WO	WO-2015018120	A1	2/2015
WO	WO-2015021612	A1	2/2015
WO	WO-2015021646	A1	2/2015
WO	WO-2015021651	A1	2/2015
WO	WO-2015021652	A1	2/2015
WO	WO-2015021655	A1	2/2015
WO	WO-2015021658	A1	2/2015
WO	WO-2015024239	A1	2/2015
WO	WO-2015024247	A1	2/2015
WO	WO-2015026081	A1	2/2015
WO	WO-2015027383	A1	3/2015
WO	WO-2015027435	A1	3/2015
WO	WO-2015027436	A1	3/2015
WO	WO-2015027470	A1	3/2015
WO	WO-2015028815	A1	3/2015
WO	WO-2015032050	A1	3/2015
WO	WO-2015032055	A1	3/2015
WO	WO-2015032078	A1	3/2015
WO	WO-2015032093	A1	3/2015
WO	WO-2015035510	A1	3/2015
WO	WO-2015035547	A1	3/2015
WO	WO-2015035557	A1	3/2015
WO	WO-2015035587	A1	3/2015
WO	WO-2015035623	A1	3/2015
WO	WO-2015035689	A1	3/2015
WO	WO-2015037925	A1	3/2015
WO	WO-2015039275	A1	3/2015
WO	WO-2015039280	A1	3/2015
WO	WO-2015039332	A1	3/2015
WO	WO-2015042790	A1	4/2015
WO	WO-2015042811	A1	4/2015
WO	WO-2015042848	A1	4/2015
WO	WO-2015042943	A1	4/2015
WO	WO-2015051509	A1	4/2015
WO	WO-2015051538	A1	4/2015
WO	WO-2015054815	A1	4/2015
WO	WO-2015054961	A1	4/2015
WO	WO-2015055314	A1	4/2015
WO	WO-2015058340	A1	4/2015
WO	WO-2015058341	A1	4/2015
WO	WO-2015058367	A1	4/2015
WO	WO-2015058387	A1	4/2015
WO	WO-2015062041	A1	5/2015
WO	WO-2015066136	A1	5/2015
WO	WO-2015066927	A1	5/2015
WO	WO-2015070398	A1	5/2015
WO	WO-2015070405	A1	5/2015
WO	WO-2015071703	A1	5/2015
WO	WO-2015073975	A1	5/2015
WO	WO-2015074187	A1	5/2015
WO	WO-2015074265	A1	5/2015
WO	WO-2015074308	A1	5/2015
WO	WO-2015077998	A1	6/2015
WO	WO-2015077999	A1	6/2015
WO	WO-2015078010	A1	6/2015
WO	WO-2015079197	A1	6/2015
WO	WO-2015089711	A1	6/2015
WO	WO-2015091346	A2	6/2015
WO	WO-2015013327	A3	7/2015
WO	WO-2015106434	A1	7/2015
WO	WO-2015106440	A1	7/2015
WO	WO-2015107551	A2	7/2015
WO	WO-2015107552	A1	7/2015
WO	WO-2015109476	A1	7/2015
WO	WO-2015109532	A1	7/2015
WO	WO-2015109540	A1	7/2015
WO	WO-2015109616	A1	7/2015
WO	WO-2015109618	A1	7/2015
WO	WO-2015117285	A1	8/2015
WO	WO-2015120588	A1	8/2015
WO	WO-2015120591	A1	8/2015
WO	WO-2015120623	A1	8/2015
WO	WO-2015123831	A1	8/2015
WO	WO-2015127609	A1	9/2015
WO	WO-2015128599	A1	9/2015
WO	WO-2015137815	A1	9/2015
WO	WO-2015140312	A1	9/2015
WO	WO-2015140336	A1	9/2015
WO	WO-2015140768	A2	9/2015
WO	WO-2015143637	A1	10/2015
WO	WO-2015143648	A1	10/2015
WO	WO-2015143749	A1	10/2015
WO	WO-2015143765	A1	10/2015
WO	WO-2015144057	A1	10/2015
WO	WO-2015149311	A1	10/2015
WO	WO-2015149330	A1	10/2015
WO	WO-2015149332	A1	10/2015
WO	WO-2015149338	A1	10/2015
WO	WO-2015149368	A1	10/2015
WO	WO-2015149403	A1	10/2015
WO	WO-2015149406	A1	10/2015
WO	WO-2015150068	A1	10/2015
WO	WO-2015154309	A1	10/2015
WO	WO-2015154619	A1	10/2015
WO	WO-2015157891	A1	10/2015
WO	WO-2015157893	A1	10/2015
WO	WO-2015157900	A1	10/2015
WO	WO-2015157901	A1	10/2015
WO	WO-2015157928	A1	10/2015
WO	WO-2015158522	A1	10/2015
WO	WO-2015158548	A1	10/2015
WO	WO-2015161406	A1	10/2015
WO	WO-2015161407	A1	10/2015
WO	WO-2015161485	A1	10/2015
WO	WO-2015161486	A1	10/2015
WO	WO-2015161491	A1	10/2015
WO	WO-2015161514	A1	10/2015
WO	WO-2015161553	A1	10/2015
WO	WO-2015161555	A1	10/2015
WO	WO-2015161557	A1	10/2015
WO	WO-2015068044	A3	11/2015
WO	WO-2015165067	A1	11/2015
WO	WO-2015165081	A1	11/2015
WO	WO-2015165083	A1	11/2015
WO	WO-2015165086	A1	11/2015
WO	WO-2015165105	A1	11/2015
WO	WO-2015165146	A1	11/2015
WO	WO-2015168827	A1	11/2015
WO	WO-2015168828	A1	11/2015
WO	WO-2015168853	A1	11/2015

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2015168904 A1	11/2015
WO	WO-2015168912 A1	11/2015
WO	WO-2015172331 A1	11/2015
WO	WO-2015172361 A1	11/2015
WO	WO-2015172368 A1	11/2015
WO	WO-2015172382 A1	11/2015
WO	WO-2015172383 A1	11/2015
WO	WO-2015172384 A1	11/2015
WO	WO-2015172387 A1	11/2015
WO	WO-2015172388 A1	11/2015
WO	WO-2015172389 A1	11/2015
WO	WO-2015172390 A1	11/2015
WO	WO-2015172606 A1	11/2015
WO	WO-2015174657 A1	11/2015
WO	WO-2015174708 A1	11/2015
WO	WO-2015175979 A1	11/2015
WO	WO-2015176210 A1	11/2015
WO	WO-2015176230 A1	11/2015
WO	WO-2015176300 A1	11/2015
WO	WO-2015176580 A1	11/2015
WO	WO-2015180027 A1	12/2015
WO	WO-2015180061 A1	12/2015
WO	WO-2015180062 A1	12/2015
WO	WO-2015180071 A1	12/2015
WO	WO-2015180088 A1	12/2015
WO	WO-2015180089 A1	12/2015
WO	WO-2015180145 A1	12/2015
WO	WO-2015184580 A1	12/2015
WO	WO-2015184590 A1	12/2015
WO	WO-2015184620 A1	12/2015
WO	WO-2015184747 A1	12/2015
WO	WO-2015188295 A1	12/2015
WO	WO-2015188296 A1	12/2015
WO	WO-2015189613 A1	12/2015
WO	WO-2015190810 A1	12/2015
WO	WO-2015192301 A1	12/2015
WO	WO-2015192326 A1	12/2015
WO	WO-2015192336 A1	12/2015
WO	WO-2015192337 A1	12/2015
WO	WO-2015192377 A1	12/2015
WO	WO-2015193456 A1	12/2015
WO	WO-2015196331 A1	12/2015
WO	WO-2015196332 A1	12/2015
WO	WO-2015196357 A1	12/2015
WO	WO-2015196367 A1	12/2015
WO	WO-2015196395 A1	12/2015
WO	WO-2015196463 A1	12/2015
WO	WO-2015148649 A3	1/2016
WO	WO-2016000113 A1	1/2016
WO	WO-2016000130 A1	1/2016
WO	WO-2016000135 A1	1/2016
WO	WO-2016000136 A1	1/2016
WO	WO-2016000139 A1	1/2016
WO	WO-2016000206 A1	1/2016
WO	WO-2016000207 A1	1/2016
WO	WO-2016000214 A1	1/2016
WO	WO-2016000232 A1	1/2016
WO	WO-2016000233 A1	1/2016
WO	WO-2016000305 A1	1/2016
WO	WO-2016008067 A1	1/2016
WO	WO-2016008096 A1	1/2016
WO	WO-2016008217 A1	1/2016
WO	WO-2016011573 A1	1/2016
WO	WO-2016012769 A1	1/2016
WO	WO-2016015196 A1	2/2016
WO	WO-2016015245 A1	2/2016
WO	WO-2016015246 A1	2/2016
WO	WO-2016015247 A1	2/2016
WO	WO-2016015264 A1	2/2016
WO	WO-2016015712 A1	2/2016
WO	WO-2016019508 A1	2/2016
WO	WO-2016019550 A1	2/2016
WO	WO-2016019573 A1	2/2016
WO	WO-2016020675 A1	2/2016
WO	WO-2016023173 A1	2/2016
WO	WO-2016023176 A1	2/2016
WO	WO-2016023177 A1	2/2016
WO	WO-2016023181 A1	2/2016
WO	WO-2016023182 A1	2/2016
WO	WO-2016023183 A1	2/2016
WO	WO-2016023212 A1	2/2016
WO	WO-2016023651 A1	2/2016
WO	WO-2016023824 A1	2/2016
WO	WO-2016023965 A1	2/2016
WO	WO-2016026104 A1	2/2016
WO	WO-2016026105 A1	2/2016
WO	WO-2016026156 A1	2/2016
WO	WO-2016026811 A1	2/2016
WO	WO-2016028544 A1	2/2016
WO	WO-2016029344 A1	3/2016
WO	WO-2016029382 A1	3/2016
WO	WO-2016029386 A1	3/2016
WO	WO-2016029389 A1	3/2016
WO	WO-2016029429 A1	3/2016
WO	WO-2016029464 A1	3/2016
WO	WO-2016029468 A1	3/2016
WO	WO-2016029470 A1	3/2016
WO	WO-2016029473 A1	3/2016
WO	WO-2016029567 A1	3/2016
WO	WO-2016030661 A1	3/2016
WO	WO-2016033721 A1	3/2016
WO	WO-2016033734 A1	3/2016
WO	WO-2016033783 A1	3/2016
WO	WO-2016033817 A1	3/2016
WO	WO-2016034100 A1	3/2016
WO	WO-2016038029 A1	3/2016
WO	WO-2016040575 A1	3/2016
WO	WO-2016041114 A1	3/2016
WO	WO-2016041140 A1	3/2016
WO	WO-2016041141 A1	3/2016
WO	WO-2016041207 A1	3/2016
WO	WO-2016041209 A1	3/2016
WO	WO-2016045058 A1	3/2016
WO	WO-2016046116 A1	3/2016
WO	WO-2015192834 A3	4/2016
WO	WO-2016049822 A1	4/2016
WO	WO-2016049823 A1	4/2016
WO	WO-2016049855 A1	4/2016
WO	WO-2016049863 A1	4/2016
WO	WO-2016050246 A1	4/2016
WO	WO-2016050247 A1	4/2016
WO	WO-2016054793 A1	4/2016
WO	WO-2016055653 A1	4/2016
WO	WO-2016058139 A1	4/2016
WO	WO-2016058187 A1	4/2016
WO	WO-2016058189 A1	4/2016
WO	WO-2016059000 A1	4/2016
WO	WO-2016060576 A1	4/2016
WO	WO-2016061729 A1	4/2016
WO	WO-2016061730 A1	4/2016
WO	WO-2016061822 A1	4/2016
WO	WO-2016061859 A1	4/2016
WO	WO-2016062168 A1	4/2016
WO	WO-2016062777 A1	4/2016
WO	WO-2016063775 A1	4/2016
WO	WO-2016065520 A1	5/2016
WO	WO-2016065521 A1	5/2016
WO	WO-2016065532 A1	5/2016
WO	WO-2016065533 A1	5/2016
WO	WO-2016065596 A1	5/2016
WO	WO-2016065598 A1	5/2016
WO	WO-2016065599 A1	5/2016
WO	WO-2016065605 A1	5/2016
WO	WO-2016065606 A1	5/2016
WO	WO-2016065607 A1	5/2016
WO	WO-2016070553 A1	5/2016
WO	WO-2016071027 A1	5/2016
WO	WO-2016071705 A1	5/2016
WO	WO-2016071706 A1	5/2016
WO	WO-2016074228 A1	5/2016
WO	WO-2016074229 A1	5/2016
WO	WO-2016074230 A1	5/2016
WO	WO-2016074234 A1	5/2016
WO	WO-2016074237 A1	5/2016

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2016076178	A1	5/2016
WO	WO-2016079001	A1	5/2016
WO	WO-2016079151	A1	5/2016
WO	WO-2016079152	A1	5/2016
WO	WO-2016079155	A1	5/2016
WO	WO-2016079468	A1	5/2016
WO	WO-2016079533	A1	5/2016
WO	WO-2016079729	A1	5/2016
WO	WO-2016058992	A3	6/2016
WO	WO-2016059003	A3	6/2016
WO	WO-2016082074	A1	6/2016
WO	WO-2016082103	A1	6/2016
WO	WO-2016082116	A1	6/2016
WO	WO-2016082136	A1	6/2016
WO	WO-2016082158	A1	6/2016
WO	WO-2016082179	A1	6/2016
WO	WO-2016082180	A1	6/2016
WO	WO-2016082183	A1	6/2016
WO	WO-2016082217	A1	6/2016
WO	WO-2016082232	A1	6/2016
WO	WO-2016082479	A1	6/2016
WO	WO-2016086382	A1	6/2016
WO	WO-2016090426	A1	6/2016
WO	WO-2016090531	A1	6/2016
WO	WO-2016090533	A1	6/2016
WO	WO-2016090593	A1	6/2016
WO	WO-2016090601	A1	6/2016
WO	WO-2016090602	A1	6/2016
WO	WO-2016090962	A1	6/2016
WO	WO-2016092259	A1	6/2016
WO	WO-2016095101	A1	6/2016
WO	WO-2016095206	A1	6/2016
WO	WO-2016095220	A1	6/2016
WO	WO-2016095234	A1	6/2016
WO	WO-2016095297	A1	6/2016
WO	WO-2016096337	A1	6/2016
WO	WO-2016096482	A1	6/2016
WO	WO-2016096497	A1	6/2016
WO	WO-2016096733	A1	6/2016
WO	WO-2016096762	A1	6/2016
WO	WO-2016099045	A1	6/2016
WO	WO-2016099276	A1	6/2016
WO	WO-2016101141	A1	6/2016
WO	WO-2016101142	A1	6/2016
WO	WO-2016101143	A1	6/2016
WO	WO-2016101144	A1	6/2016
WO	WO-2016101150	A1	6/2016
WO	WO-2016101183	A1	6/2016
WO	WO-2016101200	A1	6/2016
WO	WO-2016101202	A1	6/2016
WO	WO-2016101203	A1	6/2016
WO	WO-2016101248	A1	6/2016
WO	WO-2016103202	A1	6/2016
WO	WO-2016105191	A1	6/2016
WO	WO-2016036236	A3	7/2016
WO	WO-2016106476	A1	7/2016
WO	WO-2016106483	A1	7/2016
WO	WO-2016106493	A1	7/2016
WO	WO-2016106495	A1	7/2016
WO	WO-2016106499	A1	7/2016
WO	WO-2016106500	A1	7/2016
WO	WO-2016106512	A1	7/2016
WO	WO-2016108693	A1	7/2016
WO	WO-2016108694	A1	7/2016
WO	WO-2016109929	A1	7/2016
WO	WO-2016109930	A1	7/2016
WO	WO-2016109931	A1	7/2016
WO	WO-2016109932	A1	7/2016
WO	WO-2016109933	A1	7/2016
WO	WO-2016109942	A1	7/2016
WO	WO-2016109964	A1	7/2016
WO	WO-2016109965	A1	7/2016
WO	WO-2016110522	A1	7/2016
WO	WO-2016112491	A1	7/2016
WO	WO-2016112493	A1	7/2016
WO	WO-2016112533	A1	7/2016
WO	WO-2016112534	A1	7/2016
WO	WO-2016112541	A1	7/2016
WO	WO-2016112542	A1	7/2016
WO	WO-2016112561	A1	7/2016
WO	WO-2016112579	A1	7/2016
WO	WO-2016115689	A1	7/2016
WO	WO-2016115691	A1	7/2016
WO	WO-2016115701	A1	7/2016
WO	WO-2016115715	A1	7/2016
WO	WO-2016116754	A1	7/2016
WO	WO-2016116755	A1	7/2016
WO	WO-2016118005	A1	7/2016
WO	WO-2016119098	A1	8/2016
WO	WO-2016119099	A1	8/2016
WO	WO-2016119101	A1	8/2016
WO	WO-2016119119	A1	8/2016
WO	WO-2016119121	A1	8/2016
WO	WO-2016119144	A1	8/2016
WO	WO-2016119145	A1	8/2016
WO	WO-2016119163	A1	8/2016
WO	WO-2016119167	A1	8/2016
WO	WO-2016119170	A1	8/2016
WO	WO-2016119225	A1	8/2016
WO	WO-2016119248	A1	8/2016
WO	WO-2016119273	A1	8/2016
WO	WO-2016119496	A1	8/2016
WO	WO-2016122417	A1	8/2016
WO	WO-2016123763	A1	8/2016
WO	WO-2016123764	A1	8/2016
WO	WO-2016123770	A1	8/2016
WO	WO-2016123779	A1	8/2016
WO	WO-2016123780	A1	8/2016
WO	WO-2016123781	A1	8/2016
WO	WO-2016124017	A1	8/2016
WO	WO-2016124019	A1	8/2016
WO	WO-2016124695	A1	8/2016
WO	WO-2016124740	A1	8/2016
WO	WO-2016124741	A1	8/2016
WO	WO-2016127287	A1	8/2016
WO	WO-2016127293	A1	8/2016
WO	WO-2016127327	A1	8/2016
WO	WO-2016127360	A1	8/2016
WO	WO-2016127361	A1	8/2016
WO	WO-2016127389	A1	8/2016
WO	WO-2016127390	A1	8/2016
WO	WO-2016127396	A1	8/2016
WO	WO-2016127397	A1	8/2016
WO	WO-2016127401	A1	8/2016
WO	WO-2016127406	A1	8/2016
WO	WO-2016127468	A1	8/2016
WO	WO-2016127839	A1	8/2016
WO	WO-2016128562	A1	8/2016
WO	WO-2016131755	A1	8/2016
WO	WO-2016132026	A1	8/2016
WO	WO-2016134544	A1	9/2016
WO	WO-2016135503	A1	9/2016
WO	WO-2016138608	A1	9/2016
WO	WO-2016138665	A1	9/2016
WO	WO-2016138689	A1	9/2016
WO	WO-2016141508	A1	9/2016
WO	WO-2016141555	A1	9/2016
WO	WO-2016141556	A1	9/2016
WO	WO-2016141581	A1	9/2016
WO	WO-2016141592	A1	9/2016
WO	WO-2016141593	A1	9/2016
WO	WO-2016145611	A1	9/2016
WO	WO-2016145612	A1	9/2016
WO	WO-2016145613	A1	9/2016
WO	WO-2016145634	A1	9/2016
WO	WO-2016145656	A1	9/2016
WO	WO-2016145663	A1	9/2016
WO	WO-2016149896	A1	9/2016
WO	WO-2016149932	A1	9/2016
WO	WO-2016149942	A1	9/2016
WO	WO-2016150019	A1	9/2016
WO	WO-2016150979	A1	9/2016
WO	WO-2016154792	A1	10/2016
WO	WO-2016154797	A1	10/2016

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2016154798 A1	10/2016
WO	WO-2016154815 A1	10/2016
WO	WO-2016154895 A1	10/2016
WO	WO-2016154896 A1	10/2016
WO	WO-2016154897 A1	10/2016
WO	WO-2016154900 A1	10/2016
WO	WO-2016154994 A1	10/2016
WO	WO-2016155003 A1	10/2016
WO	WO-2016155103 A1	10/2016
WO	WO-2016155104 A1	10/2016
WO	WO-2016155105 A1	10/2016
WO	WO-2016155316 A1	10/2016
WO	WO-2016156103 A1	10/2016
WO	WO-2016156217 A1	10/2016
WO	WO-2016156413 A1	10/2016
WO	WO-2016161554 A1	10/2016
WO	WO-2016161673 A1	10/2016
WO	WO-2016162446 A1	10/2016
WO	WO-2016162492 A1	10/2016
WO	WO-2016165055 A1	10/2016
WO	WO-2016165057 A1	10/2016
WO	WO-2016165063 A1	10/2016
WO	WO-2016165125 A1	10/2016
WO	WO-2016166049 A1	10/2016
WO	WO-2016166456 A1	10/2016
WO	WO-2016166661 A1	10/2016
WO	WO-2016166670 A1	10/2016
WO	WO-2016168986 A1	10/2016
WO	WO-2016169019 A1	10/2016
WO	WO-2016169052 A1	10/2016
WO	WO-2016169063 A1	10/2016
WO	WO-2016169669 A1	10/2016
WO	WO-2016169796 A1	10/2016
WO	WO-2016169797 A1	10/2016
WO	WO-2016172802 A1	11/2016
WO	WO-2016172821 A1	11/2016
WO	WO-2016172843 A1	11/2016
WO	WO-2016172847 A1	11/2016
WO	WO-2016172867 A1	11/2016
WO	WO-2016172898 A1	11/2016
WO	WO-2016172907 A1	11/2016
WO	WO-2016172908 A1	11/2016
WO	WO-2016172909 A1	11/2016
WO	WO-2016172954 A1	11/2016
WO	WO-2016174179 A1	11/2016
WO	WO-2016176800 A1	11/2016
WO	WO-2016177604 A1	11/2016
WO	WO-2016179356 A1	11/2016
WO	WO-2016179664 A1	11/2016
WO	WO-2016179776 A1	11/2016
WO	WO-2016179828 A1	11/2016
WO	WO-2016183724 A1	11/2016
WO	WO-2016184247 A1	11/2016
WO	WO-2016184824 A1	11/2016
WO	WO-2016171997 A3	12/2016
WO	WO-2016187803 A1	12/2016
WO	WO-2016187943 A1	12/2016
WO	WO-2016188140 A1	12/2016
WO	WO-2016188141 A1	12/2016
WO	WO-2016188142 A1	12/2016
WO	WO-2016188967 A1	12/2016
WO	WO-2016189086 A1	12/2016
WO	WO-2016191946 A1	12/2016
WO	WO-2016193336 A1	12/2016
WO	WO-2016193365 A1	12/2016
WO	WO-2016193743 A1	12/2016
WO	WO-2016197485 A1	12/2016
WO	WO-2016197658 A1	12/2016
WO	WO-2016198417 A1	12/2016
WO	WO-2016198459 A1	12/2016
WO	WO-2016198879 A1	12/2016
WO	WO-2016199062 A1	12/2016
WO	WO-2016199065 A1	12/2016
WO	WO-2016199066 A1	12/2016
WO	WO-2016200252 A1	12/2016
WO	WO-2016200253 A1	12/2016
WO	WO-2016200255 A1	12/2016
WO	WO-2016200259 A1	12/2016
WO	WO-2016200382 A1	12/2016
WO	WO-2016201602 A1	12/2016
WO	WO-2016201606 A1	12/2016
WO	WO-2016201911 A1	12/2016
WO	WO-2016202028 A1	12/2016
WO	WO-2016202033 A1	12/2016
WO	WO-2016202301 A1	12/2016
WO	WO-2016202302 A1	12/2016
WO	WO-2016202303 A1	12/2016
WO	WO-2016202304 A1	12/2016
WO	WO-2016207357 A1	12/2016
WO	WO-2016208757 A1	12/2016
WO	WO-2016208760 A1	12/2016
WO	WO-2016193705 A3	1/2017
WO	WO-2017000239 A1	1/2017
WO	WO-2017001270 A1	1/2017
WO	WO-2017001817 A1	1/2017
WO	WO-2017001818 A1	1/2017
WO	WO-2017001819 A1	1/2017
WO	WO-2017001820 A1	1/2017
WO	WO-2017005835 A1	1/2017
WO	WO-2017007252 A1	1/2017
WO	WO-2017008616 A1	1/2017
WO	WO-2017009002 A1	1/2017
WO	WO-2017011419 A1	1/2017
WO	WO-2017012099 A1	1/2017
WO	WO-2017012105 A1	1/2017
WO	WO-2017012257 A1	1/2017
WO	WO-2017012335 A1	1/2017
WO	WO-2016172921 A8	2/2017
WO	WO-2016178098 A3	2/2017
WO	WO-2017015791 A1	2/2017
WO	WO-2017015794 A1	2/2017
WO	WO-2017015832 A1	2/2017
WO	WO-2017015859 A1	2/2017
WO	WO-2017016323 A1	2/2017
WO	WO-2017017970 A1	2/2017
WO	WO-2017020220 A1	2/2017
WO	WO-2017020221 A1	2/2017
WO	WO-2017020275 A1	2/2017
WO	WO-2017020290 A1	2/2017
WO	WO-2017023589 A1	2/2017
WO	WO-2017024477 A1	2/2017
WO	WO-2017024478 A1	2/2017
WO	WO-2017024799 A1	2/2017
WO	WO-2017024926 A1	2/2017
WO	WO-2017025383 A1	2/2017
WO	WO-2017028167 A1	2/2017
WO	WO-2017028295 A1	2/2017
WO	WO-2017029268 A1	2/2017
WO	WO-2017029269 A1	2/2017
WO	WO-2017029270 A1	2/2017
WO	WO-2017021536 A3	3/2017
WO	WO-2017031662 A1	3/2017
WO	WO-2017031678 A1	3/2017
WO	WO-2017031681 A1	3/2017
WO	WO-2017033007 A1	3/2017
WO	WO-2017033021 A1	3/2017
WO	WO-2017033132 A1	3/2017
WO	WO-2017035720 A1	3/2017
WO	WO-2017036818 A1	3/2017
WO	WO-2017036819 A1	3/2017
WO	WO-2017036828 A1	3/2017
WO	WO-2017036829 A1	3/2017
WO	WO-2017036865 A1	3/2017
WO	WO-2017036879 A1	3/2017
WO	WO-2017041251 A1	3/2017
WO	WO-2017042081 A1	3/2017
WO	WO-2017045132 A1	3/2017
WO	WO-2017045897 A1	3/2017
WO	WO-2017045898 A1	3/2017
WO	WO-2017045899 A1	3/2017
WO	WO-2017046247 A1	3/2017
WO	WO-2017046334 A1	3/2017
WO	WO-2017046363 A1	3/2017
WO	WO-2017046566 A1	3/2017

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2017049653 A1	3/2017
WO	WO-2017049654 A1	3/2017
WO	WO-2017051150 A1	3/2017
WO	WO-2017051174 A1	3/2017
WO	WO-2017051348 A1	3/2017
WO	WO-2017051349 A1	3/2017
WO	WO-2017046593 A3	4/2017
WO	WO-2017054424 A1	4/2017
WO	WO-2017054627 A1	4/2017
WO	WO-2017054634 A1	4/2017
WO	WO-2017055564 A1	4/2017
WO	WO-2017055584 A1	4/2017
WO	WO-2017055793 A1	4/2017
WO	WO-2017055795 A1	4/2017
WO	WO-2017055799 A1	4/2017
WO	WO-2017055801 A1	4/2017
WO	WO-2017055802 A1	4/2017
WO	WO-2017055803 A1	4/2017
WO	WO-2017055866 A1	4/2017
WO	WO-2017056103 A1	4/2017
WO	WO-2017057286 A1	4/2017
WO	WO-2017059571 A1	4/2017
WO	WO-2017060279 A1	4/2017
WO	WO-2017063256 A1	4/2017
WO	WO-2017063535 A1	4/2017
WO	WO-2017064051 A1	4/2017
WO	WO-2017064322 A1	4/2017
WO	WO-2017064323 A1	4/2017
WO	WO-2017064324 A1	4/2017
WO	WO-2017064487 A1	4/2017
WO	WO-2017066938 A1	4/2017
WO	WO-2017066955 A1	4/2017
WO	WO-2017067066 A1	4/2017
WO	WO-2017067326 A1	4/2017
WO	WO-2017068098 A1	4/2017
WO	WO-2017068099 A1	4/2017
WO	WO-2017068100 A1	4/2017
WO	WO-2016096745 A9	5/2017
WO	WO-2016173568 A3	5/2017
WO	WO-2016198026 A3	5/2017
WO	WO-2017051350 A3	5/2017
WO	WO-2017070871 A1	5/2017
WO	WO-2017071297 A1	5/2017
WO	WO-2017071298 A1	5/2017
WO	WO-2017072239 A1	5/2017
WO	WO-2017072277 A1	5/2017
WO	WO-2017072284 A1	5/2017
WO	WO-2017075753 A1	5/2017
WO	WO-2017075759 A1	5/2017
WO	WO-2017075827 A1	5/2017
WO	WO-2017075883 A1	5/2017
WO	WO-2017075975 A1	5/2017
WO	WO-2017076247 A1	5/2017
WO	WO-2017076590 A1	5/2017
WO	WO-2017081480 A1	5/2017
WO	WO-2017082728 A1	5/2017
WO	WO-2017084107 A1	5/2017
WO	WO-2017084488 A1	5/2017
WO	WO-2017084489 A1	5/2017
WO	WO-2017084818 A1	5/2017
WO	WO-2017084848 A1	5/2017
WO	WO-2017084849 A1	5/2017
WO	WO-2017084920 A2	5/2017
WO	WO-2017085240 A1	5/2017
WO	WO-2017085242 A1	5/2017
WO	WO-2017081176 A3	6/2017
WO	WO-2017088660 A1	6/2017
WO	WO-2017089931 A1	6/2017
WO	WO-2017091926 A1	6/2017
WO	WO-2017092144 A1	6/2017
WO	WO-2017093452 A1	6/2017
WO	WO-2017093535 A1	6/2017
WO	WO-2017096512 A1	6/2017
WO	WO-2017096971 A1	6/2017
WO	WO-2017096988 A1	6/2017
WO	WO-2017097172 A1	6/2017
WO	WO-2017097173 A1	6/2017
WO	WO-2017097821 A1	6/2017
WO	WO-2017101030 A1	6/2017
WO	WO-2017101058 A1	6/2017
WO	WO-2017101705 A1	6/2017
WO	WO-2017102633 A1	6/2017
WO	WO-2017102686 A1	6/2017
WO	WO-2017102969 A1	6/2017
WO	WO-2017107546 A1	6/2017
WO	WO-2017108268 A1	6/2017
WO	WO-2017108392 A1	6/2017
WO	WO-2017108394 A1	6/2017
WO	WO-2017108429 A1	6/2017
WO	WO-2017109448 A2	6/2017
WO	WO-2017109868 A1	6/2017
WO	WO-2017110713 A1	6/2017
WO	WO-2017036426 A3	7/2017
WO	WO-2017113106 A1	7/2017
WO	WO-2017113513 A1	7/2017
WO	WO-2017113845 A1	7/2017
WO	WO-2017114389 A1	7/2017
WO	WO-2017117725 A1	7/2017
WO	WO-2017117742 A1	7/2017
WO	WO-2017118135 A1	7/2017
WO	WO-2017118138 A1	7/2017
WO	WO-2017118347 A1	7/2017
WO	WO-2017121156 A1	7/2017
WO	WO-2017121253 A1	7/2017
WO	WO-2017121296 A1	7/2017
WO	WO-2017121546 A1	7/2017
WO	WO-2017121979 A1	7/2017
WO	WO-2017122196 A1	7/2017
WO	WO-2017124419 A1	7/2017
WO	WO-2017124662 A1	7/2017
WO	WO-2017124957 A1	7/2017
WO	WO-2017128038 A1	8/2017
WO	WO-2017133056 A1	8/2017
WO	WO-2017137138 A1	8/2017
WO	WO-2017137554 A1	8/2017
WO	WO-2017139963 A1	8/2017
WO	WO-2017141017 A1	8/2017
WO	WO-2017141018 A1	8/2017
WO	WO-2017141358 A1	8/2017
WO	WO-2017143494 A1	8/2017
WO	WO-2017143495 A1	8/2017
WO	WO-2017143515 A1	8/2017
WO	WO-2017143865 A1	8/2017
WO	WO-2017143953 A1	8/2017
WO	WO-2017144400 A1	8/2017
WO	WO-2017144861 A1	8/2017
WO	WO-2017149288 A1	9/2017
WO	WO-2017152481 A1	9/2017
WO	WO-2017153051 A1	9/2017
WO	WO-2017153270 A1	9/2017
WO	WO-2017156694 A1	9/2017
WO	WO-2017156695 A1	9/2017
WO	WO-2017156696 A1	9/2017
WO	WO-2017156733 A1	9/2017
WO	WO-2017156743 A1	9/2017
WO	WO-2017161715 A1	9/2017
WO	WO-2017161725 A1	9/2017
WO	WO-2017163044 A1	9/2017
WO	WO-2017163045 A1	9/2017
WO	WO-2017163046 A1	9/2017
WO	WO-2017163047 A1	9/2017
WO	WO-2017163050 A1	9/2017
WO	WO-2017163051 A1	9/2017
WO	WO-2017163052 A1	9/2017
WO	WO-2017164474 A1	9/2017
WO	WO-2017166263 A1	10/2017
WO	WO-2017166334 A1	10/2017
WO	WO-2017167169 A1	10/2017
WO	WO-2017167513 A1	10/2017
WO	WO-2017173669 A1	10/2017
WO	WO-2017173947 A1	10/2017
WO	WO-2017173951 A1	10/2017
WO	WO-2017174754 A1	10/2017
WO	WO-2017175166 A1	10/2017

(56) **References Cited**

FOREIGN PATENT DOCUMENTS

WO	WO-2017176111 A1	10/2017
WO	WO-2017176113 A1	10/2017
WO	WO-2017177897 A1	10/2017

OTHER PUBLICATIONS

"Guideline Accompanying Commission Regulation (EC) No. 1275/2008," Official Journal of the European Union, Oct. 2009.

"Lighter." Merriam-Webster Online Dictionary. 2009. Merriam-Webster Online. Jun. 8, 2009 [http://www.merriam-webster.com/dictionary/lighter].

AMB. Manual:TranX160/Rev.10-06. published 2004-2006.

Baker et al., "The pyrolysis of tobacco ingredients," J. Anal. Appl. Pyrolysis, vol. 71, pp. 223-311 (2004).

Bombick, et al. Chemical and biological studies of a new cigarette that primarily heats tobacco. Part 2. In vitro toxicology of mainstream smoke condensate. Food and Chemical Toxicology. 1997; 36:183-190.

Bombick, et al. Chemical and biological studies of a new cigarette that primarily heats tobacco. Part 3. In vitro toxicity of whole smoke. Food and Chemical Toxicology. 1998; 36:191-197.

Borgerding, et al. Chemical and biological studies of a new cigarette that primarily heats tobacco. Part 1. Chemical composition of mainstream smoke. Food and Chemical Toxicology. 1997; 36:169-182.

Breland, Alison, et al. "Electronic cigarettes: what are they and what do they do?." Annals of the New York Academy of Sciences 1394.1 (2017): 5-30.

Brown, Christopher J., et al., "Electronic cigarettes: product characterisation and design considerations." Tobacco control 23.suppl 2 (2014): ii4-ii10.

Bullen, et al., "Effect of an electronic nicotine delivery device (e cigarette) on desire to smoke and withdrawal, user preferences and nicotine delivery: randomized cross-over trial," Tobacco Control, 19(2), pp. 98-103. Apr. 2010.

Burch, et al., "Effect of pH on nicotine absorption and side effects produced by areosolized nicotine," Journal of Aerosol Medicine: Deposition, Clearance, and Effects in the Lung, 6(1), pp. 45-52. 1993.

Capponnetto, et al., "Successful smoking cessation with cigarettes in smokers with a documented history of recurring relapses: a case series," Journal of Medical Case Reports; 5(1), 6 pages. 2011.

Davis & Nielsen, "Marketing, Processing and Storage: Green Leaf Threshing and Redrying Tobacco," Tobacco Production, Chemistry and Technology, (1999) Section 10B, pp. 330-333, Bill Ward, Expert Leaf Tobacco Company, Wilson, North Carolina, USA.

E-Cigarette Forum; pg-gv-peg (discussion/posting); retrieved from the Internet: https://e-cigarette-forum.com/forum/threads/pg-vg-peg.177551; 7 pgs.; Apr. 8, 2011.

ECF; Any interest in determining nicotine—by DVAP; (https://www.e-cigarette-forum.com/forum/threads/any-interest-in-determin- ing-nicotine-by-dvap.35922/); blog posts dated: 2009; 8 pgs.; print/retrieval date: Jul. 31, 2014.

Electronic Vaporization Device/ Gizmodo Pax 2 Vaporizer/ Gizmodo; retrieved from http://gizmodo.com/pax-2-vaporizer-reviews-its-like-smoking-in-the-future-1718310779; posted Jul. 23, 2015, retrieved Oct. 17, 2016.

Farsalinos, et al., "Electronic cigarettes do not damage the heart," European Society of Cardiology, 4 pages, (http://www.escardio.org/The-ESC/Press-Office/Press-releases/Electronic-cigarettes-do-not-damage-the-heart). Aug. 25, 2012.

Farsalinos, Konstantinos E., et al. "Protocol proposal for, and evaluation of, consistency in nicotine delivery from the liquid to the aerosol of electronic cigarettes atomizers: regulatory implications." Addiction 111.6 (2016): 1069-1076.

Farsalinos, Konstantinos E., et al. *Analytical Assessment of e-Cigarettes: From Contents to Chemical and Particle Exposure Profiles*. pp. 1-35. Elsevier, 2016.

FC Vaporizer Review Forum; Pax Vaporizer by Ploom; retrieved from : http://fuckcombustion.com/threads/pax-vaporizer-by-ploom.6223/; pp. 2 & 11 (2 pgs.); retrieval date: Nov. 16, 2015.

Flouris, et al., "Acute impact of active and passive electronic cigarette smoking on serum cotinine and lung function," Inhal. Toxicol., 25(2), pp. 91-101. Feb. 2013.

Food & Drug Administration; Warning letter to the Compounding Pharmacy, retrieved Oct. 10, 2014 from http://www.fda.gov/ICECI/EnforcementActions/WarningLetters/2002/ucm144843.htm, 3 pages. Apr. 9, 2002.

Geiss, Otmar, Ivana Bianchi, and Josefa Barrero-Moreno. "Correlation of volatile carbonyl yields emitted by e-cigarettes with the temperature of the heating coil and the perceived sensorial quality of the generated vapours." *International journal of hygiene and environmental health* 219.3 (2016): 268-277.

Gillman, I. G., et al. "Effect of variable power levels on the yield of total aerosol mass and formation of aldehydes in e-cigarette aerosols." *Regulatory Toxicology and Pharmacology* 75 (2016): 58-65.

Giorgio, Agostino. "E-Cig Digital Design for the Smoke Control Optimization." *International Journal of Applied Engineering Research* 11.8 (2016): 6018-6023.

Goniewicz, et al., "Nicotine levels in electronic cigarettes," Nicotine Tobacco Research, 15(1), pp. 158-166, Jan. 2013.

Gregory, Andrew, "E-cigarettes to go on prescription under move to class them as medicines," Mirror, Jun. 12, 2013. http://www.mirror.co.uk/news/uk-news/e-cigarettes-go-prescription-under-move-1949018.

Grotenhermen, et al., Developing science-based per se limits for driving under the influence of cannabis (DUIC): findings and recommendations by an expert panel; retreived Feb. 9, 2017 from (http://www.canorml.org/healthfacts/DUICreport.2005.pdf); Sep. 2005.

Harvest Vapor, American Blend Tobacco (product info), retrieved from the internet (http://harvestvapor.com/), 2 pages. Oct. 10, 2014.

Hurt, et al., "Treating tobacco dependence in a medical setting," CA: A Cancer Journal for Clinicians, 59(5), pp. 314-326. Sep. 2009.

IJOY. "Who we are." *IJOY Diamond PD270 Kit*, Date Accessed Feb. 20, 2018. www.ijoycig.com/product/item-473.html.

Inchem; Benzoic Acid; JECFA Evaluation Summary; retrieved Oct. 10, 2014 from http://www.inchem.org/documents/jecfa/feceval/jec_184.htm, 2 pages. May 28, 2005.

Inchem; Levulinic Acid; JECFA Evaluation Summary; retrieved Oct. 10, 2014 from http://www.inchem.org/documents/jecfa/feceval/jec_1266.htm, 2 pages. Mar. 10, 2003.

Inchem; Pyruvic Acid; JECFA Evaluation Summary; retrieved Oct. 10, 2014 from http://www.inchem.org/documents/jecfa/feceval/jec_2072.htm, 2 pages. Jan. 29, 2003.

Inchem; Sorbic Acid; JECFA Evaluation Summary; retrieved Oct. 10, 2014 from http://www.inchem.org/documents/jecfa/feceval/jec_2181.htm, 2 pages. May 29, 2005.

Ingebrethsen et al., "Electronic Cigarette aerosol particle size distribution measurements", Inhalation Toxicology, 2012; 24 (14): 976-984.

Kanger K1 Stabilized Wood DNA 75 BOX MOD—KangerTech. Date Accessed Feb. 20, 2018. https://kangeronline.com/products/kanger-k1-stabilized-wood-dna-75-box-mod.

Kuo et al. Applications of Turbulent and Multiphase Combustion, Appendix D: Particle Size—U.S. Sieve Size and Tyler Screen Mesh Equivalents, 2012, p. 541-543.

Marshall, John R., Shahram Lotfipour, and Bharath Chakravarthy. "Growing Trend of Alternative Tobacco Use Among the Nation's Youth: A New Generation of Addicts." *Western Journal of Emergency Medicine* 17.2 (2016): 139.

McCann et al., "Detection of carcinogens as mutagens in the *Salmonella*/microsome test: Assay of 300 chemicals: discussion." Proct. Nat. Acad. Sci, USA, Mar. 1976, vol. 73 (3), 950-954.

Mylaps, "Rechargeable Transponder Battery Status and Charging Instructions," Sep. 9, 2010.

Nicoli et al., Mammalian tumor xenografts induce neovascularization in Zebrafish embryos. Cancer Research, 67:2927-2931 (2007).

PAX Labs, Inc.; JUUL product information © 2016; retrieved from https://www.juulvapor.com/shop-juul/; 6 pgs.; retrieved Mar. 9, 2016.

(56) **References Cited**

OTHER PUBLICATIONS

Perfetti, "Structural study of nicotine salts," Beitrage Zur Tabakforschung International, Contributions to Tobacco Research, 12(2), pp. 43-54. Jun. 1983.

Polosa, Riccardo, et al. "Effect of an electronic nicotine delivery device (e-Cigarette) on smoking reduction and cessation: a prospective 6-month pilot study." BMC public health 11.1 (2011): 786.

Poynton, Simon, et al. "A novel hybrid tobacco product that delivers a tobacco flavour note with vapour aerosol (part 1): Product operation and preliminary aerosol chemistry assessment." Food and Chemical Toxicology (2017).

Poynton, Simon, et al. "A novel hybrid tobacco product that delivers a tobacco flavour note with vapour aerosol (Part 1): product operation and preliminary aerosol chemistry assessment." *Food and Chemical Toxicology* 106 (2017): 522-532.

Seeman, et al., "The form of nicotine in tobacco. Thermal transfer of nicotine and nicotine acid salts to nicotine in the gas phase," J Aric Food Chem, 47(12), pp. 5133-5145. Dec. 1999.

Smok. *Pro Color—Smok® Innovation keeps changing the vaping experience!*, Date Accessed Feb. 20, 2018. www.smoktech.com/kit/procolor.

SRNT Subcommittee on Biochemical Verification, "Biochemical verification of tobacco use and cessation," Nicotine & Tobacco Research 4, pp. 149-159, 2002.

Tarantola, Andrew. "The Pax 2 vaporizer makes its predecessor look half-Baked." Engadget, Jul. 14, 2016, www.engadget.com/2015/04/20/pax-2-vaporizer-review/. Accessed Sep. 5, 2017.

Torikai et al., "Effects of temperature, atmosphere and pH on the generation of smoke compounds during tobacco pyrolysis," Food and Chemical Toxicology 42 (2004) 1409-1417.

Vansickel, et al. "A clinical laboratory model for evaluating the acute effects of electronic cigarettes: Nicotine delivery profile and cardiovascular and subjective effects," Cancer Epidemiology Biomarkers Prevention, 19(9), pp. 1945-1953. Jul. 20, 2010.

Vansickel, et al., "Electronic cigarettes: effective nicotine delivery after acute administration," Nicotine & Tobacco Research, 15(1), pp. 267-270. Jan. 2013.

VapeWorld; Original PAX Vaporizers for Portable and Home Use; retrieved from: https://www.vapeworld.com/pax-vaporizer-by-ploom?gclid=CPCi1PKojskCFU06gQodPr; 9 pgs.; retrieved Nov. 13, 2015.

Vaporesso (Shenzhen Smoore Technology Limited). "Target Pro Vape Mod." *Vape Batteries & Mods | Target Pro Vape Mod | Vaporesso*, Date Accessed Feb. 20, 2018. www.vaporesso.com/vape-batteries-and-mods/target-pro-vape-mod.

Vaporesso (Shenzhen Smoore Technology Limited). "Tarot Pro Vape Mod." *Vape Batteries & Mods | Tarot Pro Vape Mod | Vaporeso*, Date Accessed Feb. 20, 2018. www.vaporesso.com/vape-batteries-and-mods/tarot-pro-vape-mod.

Wells. "Glycerin as a Constituent of Cosmetics and Toilet Preparations." Journal of the Society of Cosmetic Chemists, 1958; 9(1): 19-25.

Williams, Monique, and Prue Talbot. "Variability among electronic cigarettes in the pressure drop, airflow rate, and aerosol production." Nicotine & Tobacco Research 13.12 (2011).

Youtube, "Pax 2 Unboxing," retreived from www.youtube.com/watch?v=Vjccs8co3YY, posted Apr. 20, 2015.

YouTube; Firefly Vaporizor Review w/ Usage Tips by the Vape Critic; retrieved from the internet (http://www.youtube.com/watch?v=1J38N0AV7wl); published Dec. 10, 2013; download/ print date: Feb. 18, 2015.

Youtube; Pax by Ploom Vaporizer Review; posted Aug. 14, 2013, retrieved Sep. 8, 2016, https://www.youtube.com/watch?v=Jm06zW3-cxQ.

Zhang, et al., "In vitro partical size distributions in electronic and conventional cigarette aerosols suggest comparable deposition patterns," Nicotine Tobacci Research, 15(2), pp. 501-508. Feb. 2013.

Engadget. *Juul is the e-cig that will finally stop me from smoking* (*I hope*). [online], published on Jun. 3, 2015. Available at: https://www.engadget.com/2015/06/03/pax-labs-juul-ecigarette/#/.

Pierce, D. *This Might Just Be the First Great E-Cig*. {online} Wired, Published on Apr. 21, 2015. Available at: https://www.wired.com/2015/04/pax-juul-ecig/?mbid=social_twitter.

The Verge. *Startup behind the Lambo of vaporizers just launched an intelligent e-cigarette*. [online], published on Apr. 21, 2015. Available at: https://www.theverge.com/2015/4/21/8458629/pax-labs-e-cigarette-juul.

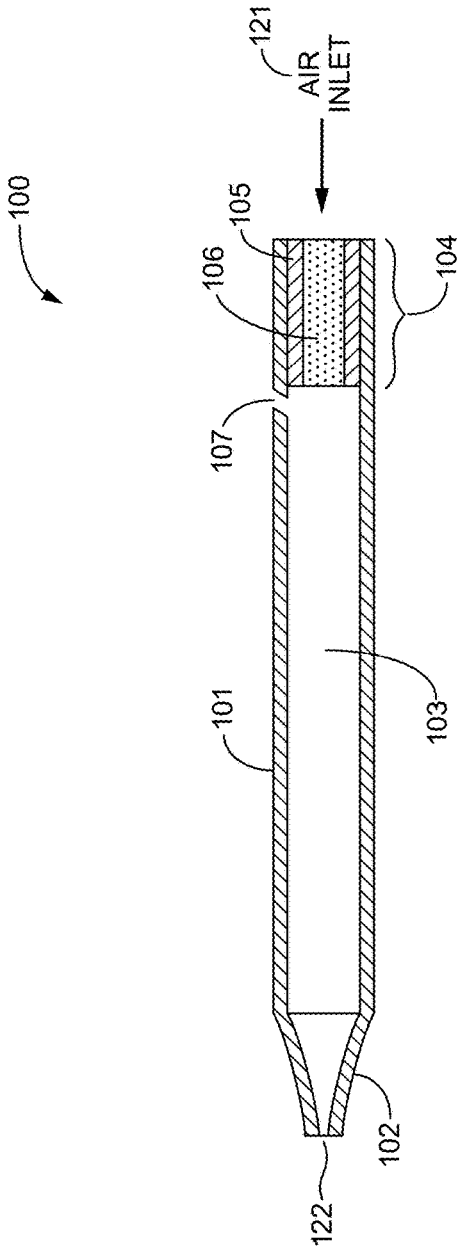
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FIG. 1

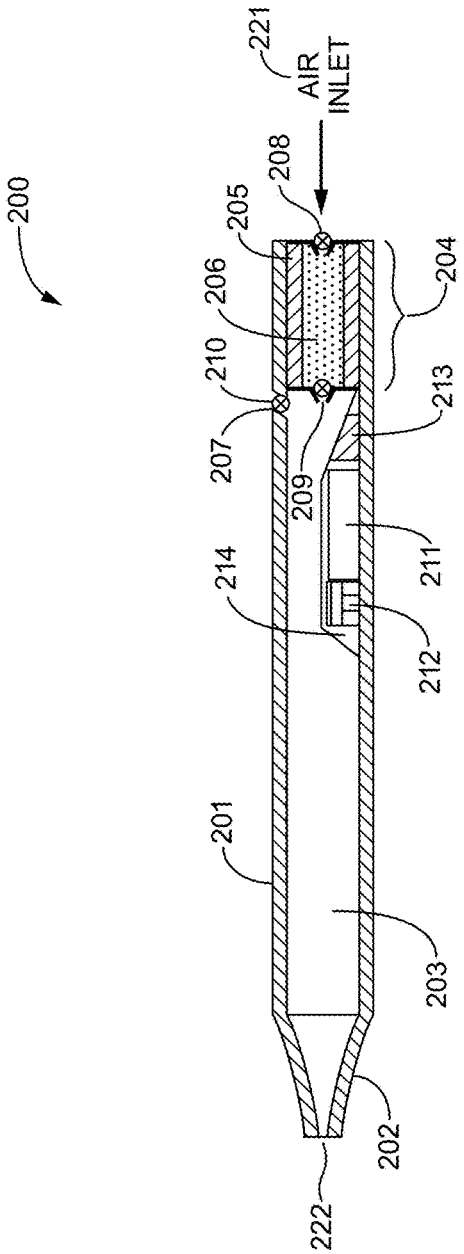
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FIG. 2

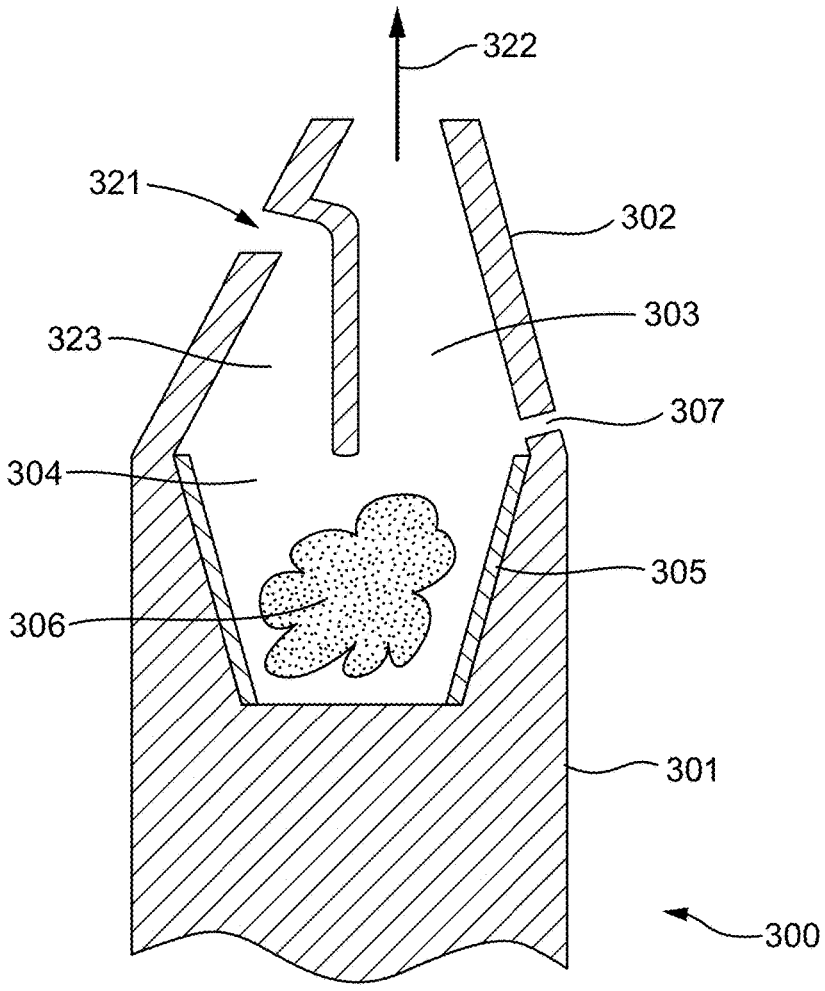


FIG. 3

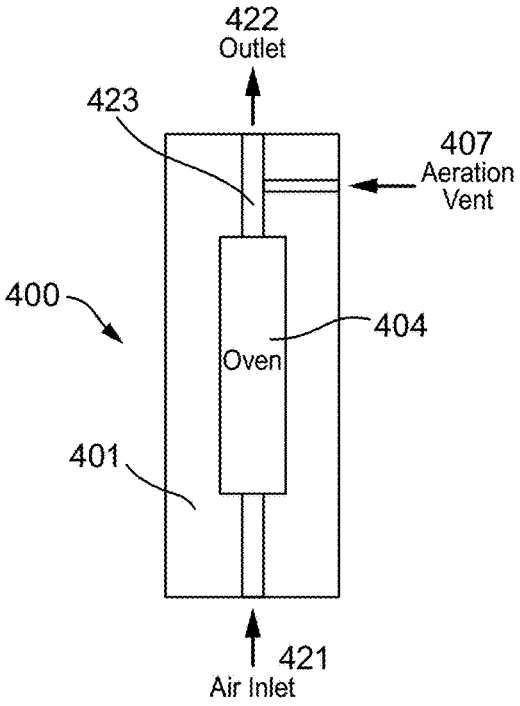


FIG. 4A

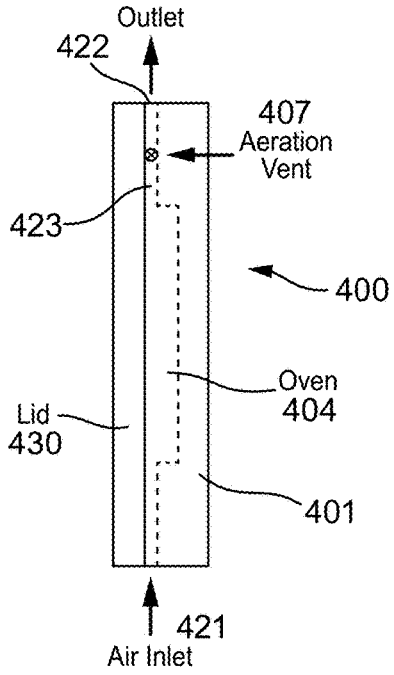


FIG. 4B

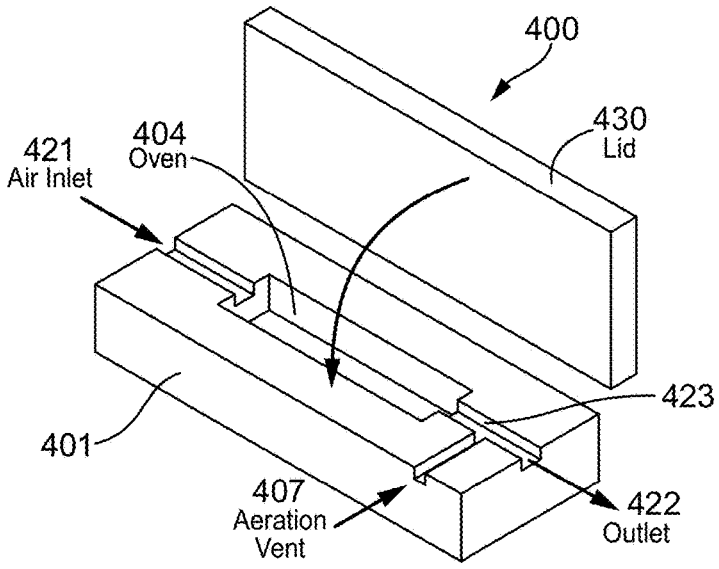


FIG. 4C

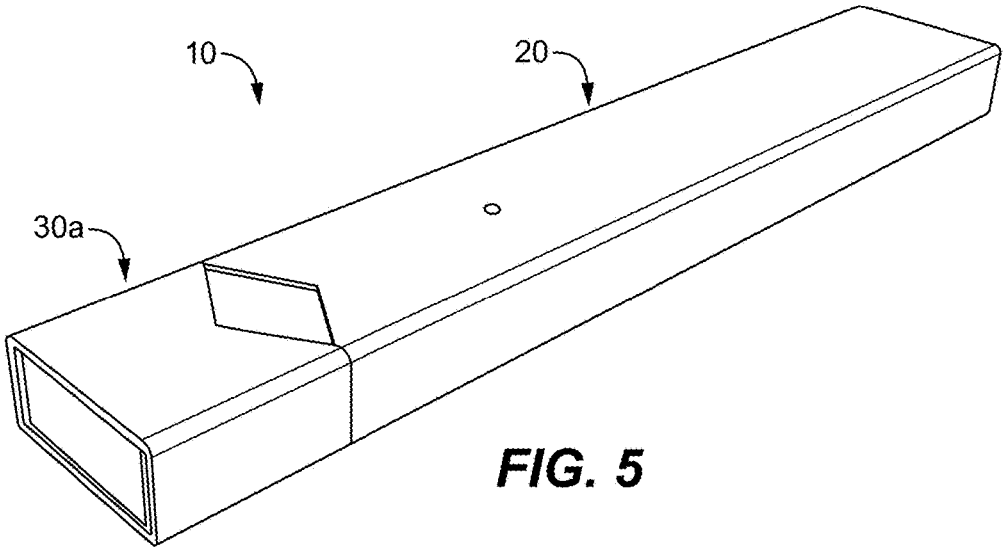


FIG. 5

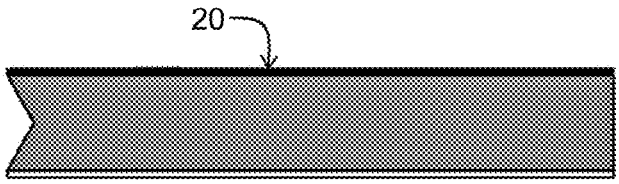


FIG. 6A

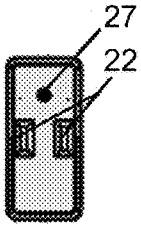


FIG. 6C

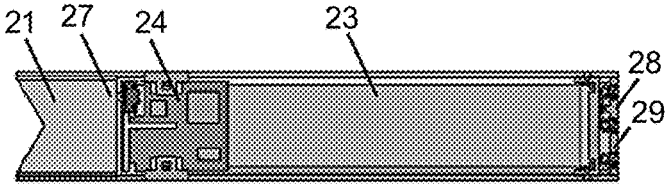
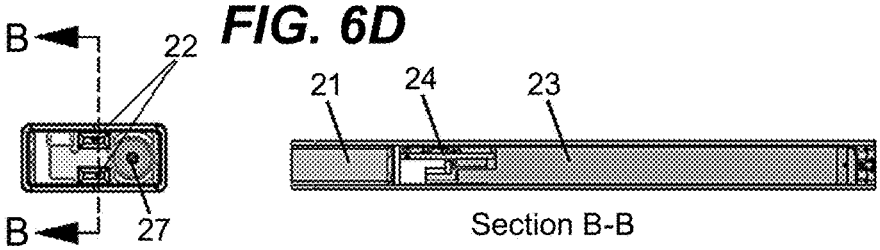


FIG. 6B

FIG. 6D



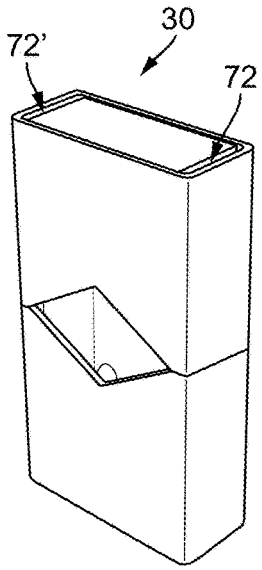


FIG. 7A

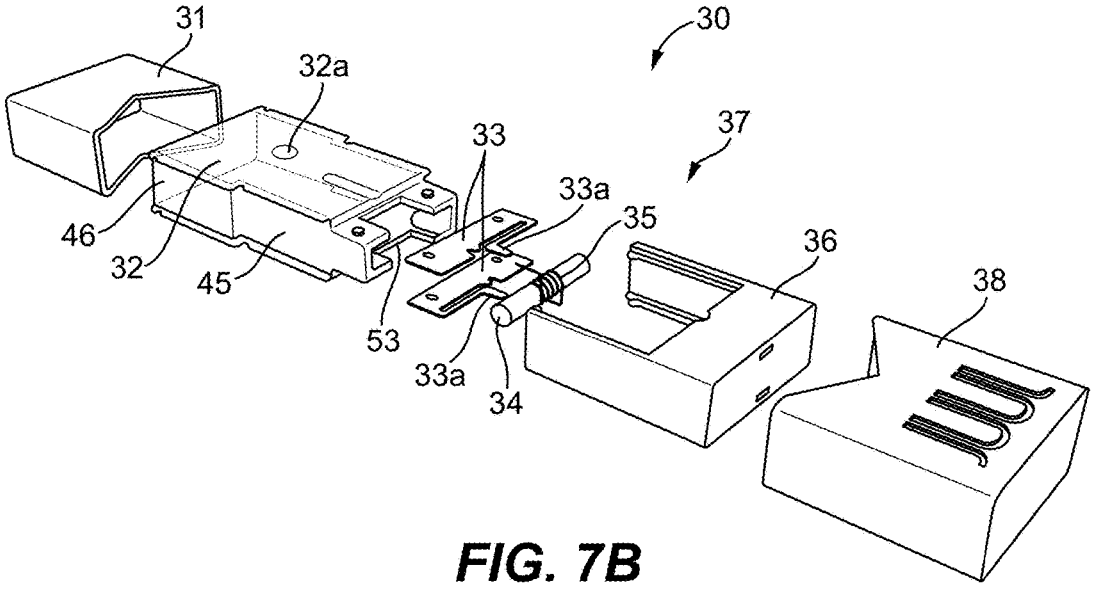


FIG. 7B

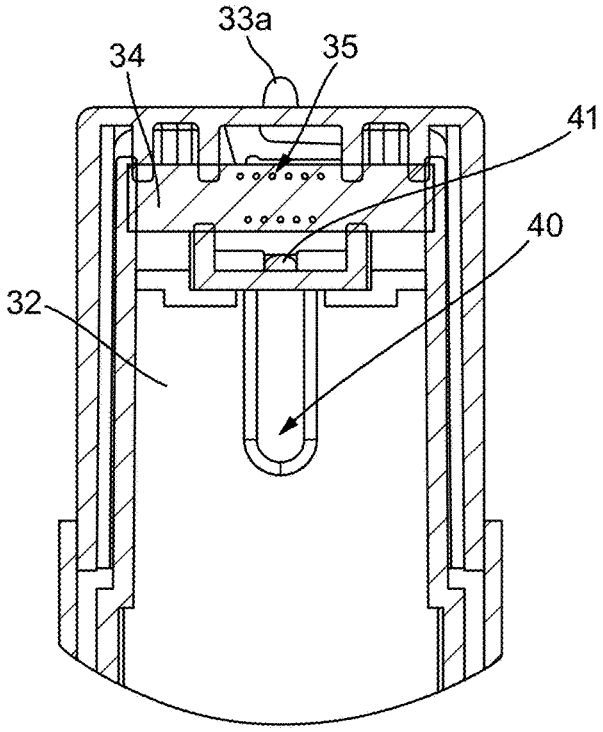


FIG. 7C

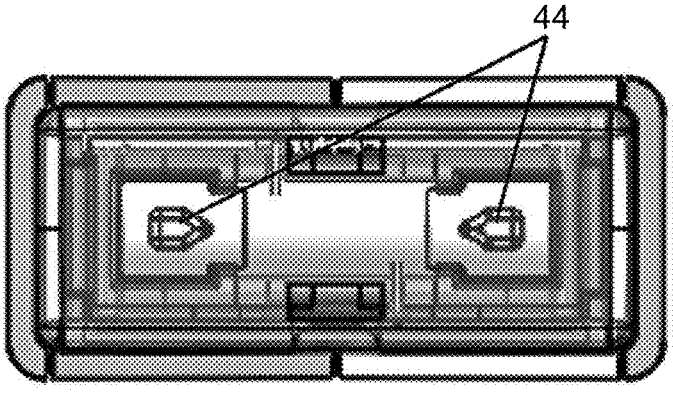


FIG. 8A

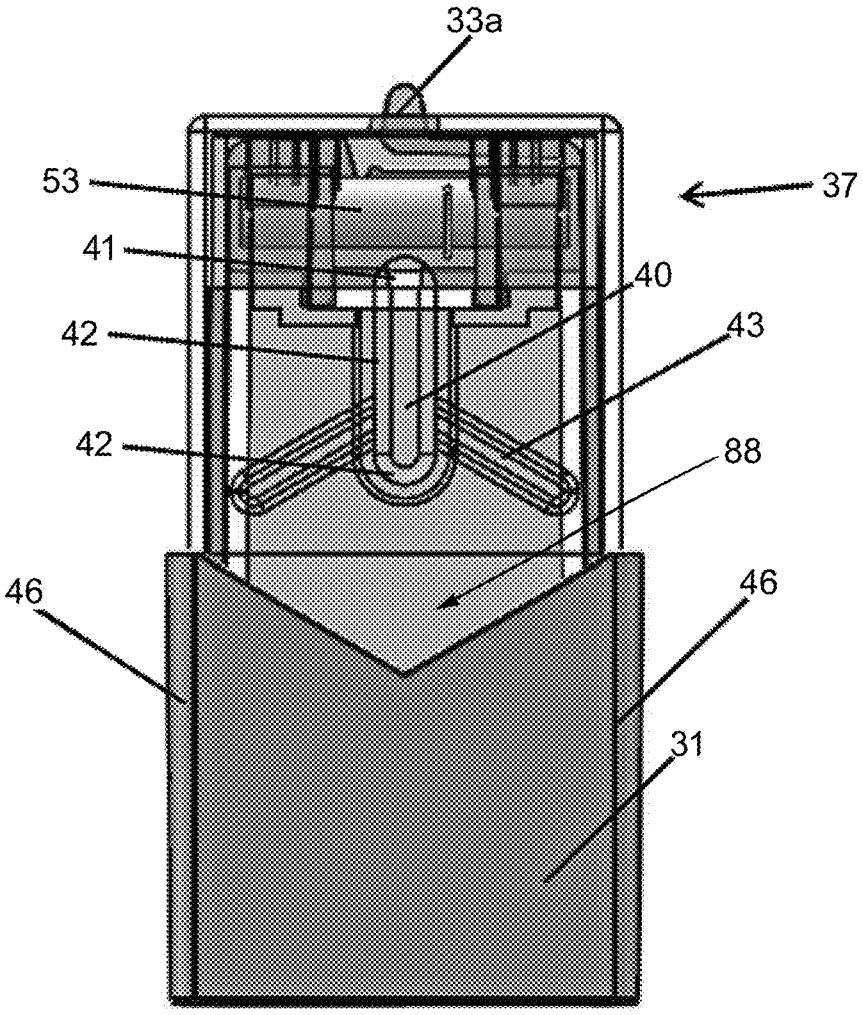


FIG. 8B

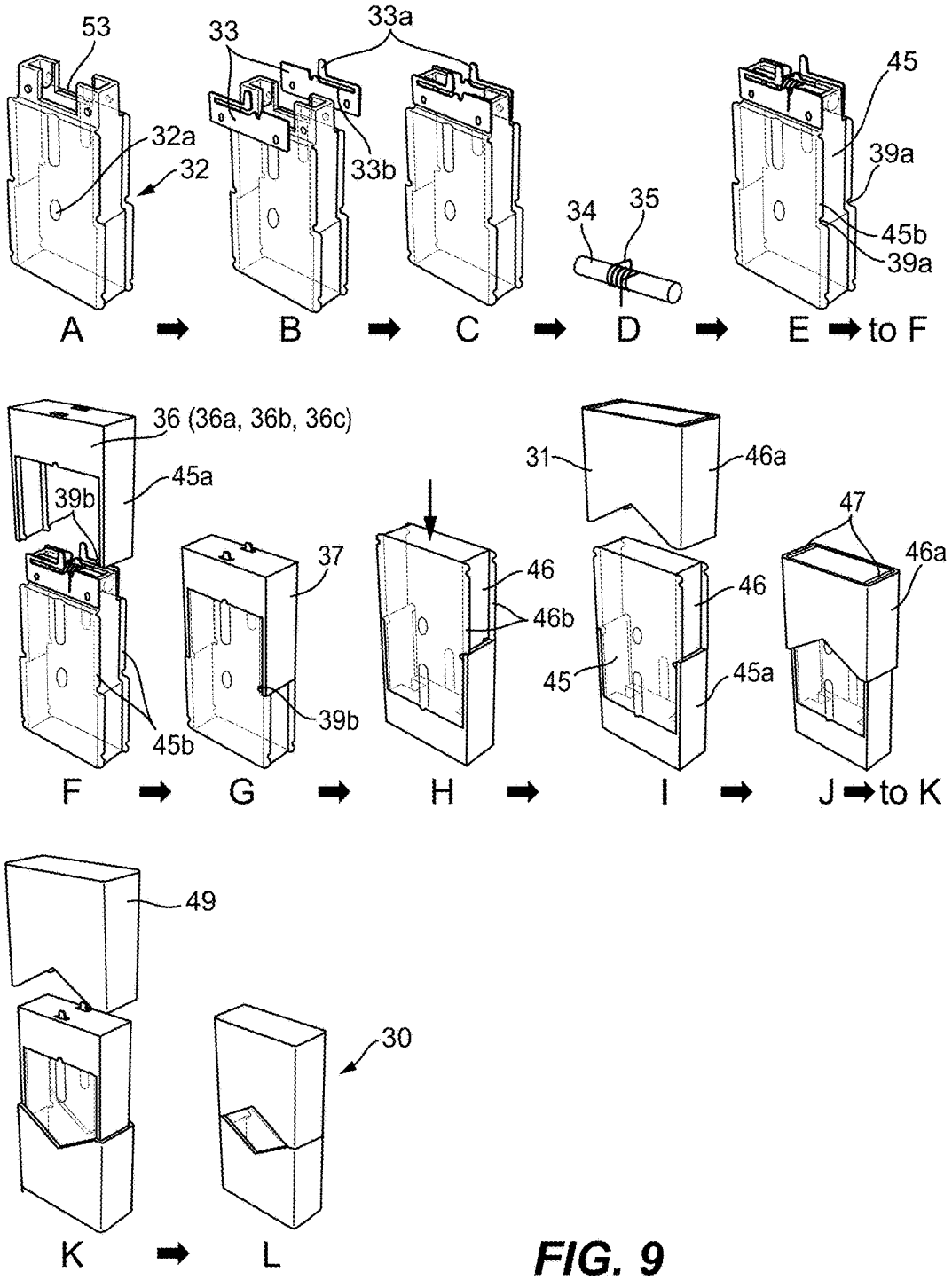

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FIG. 9

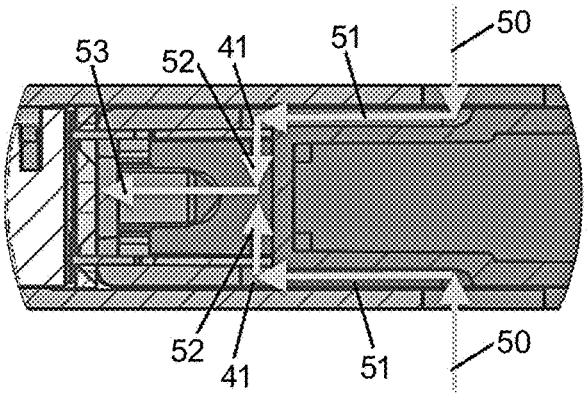
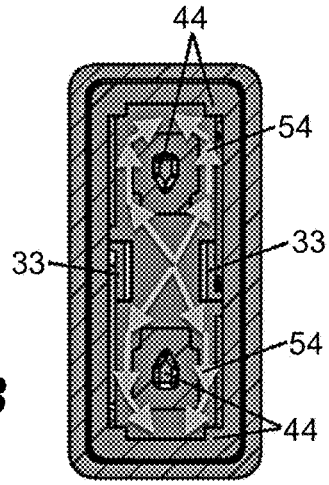


FIG. 10A



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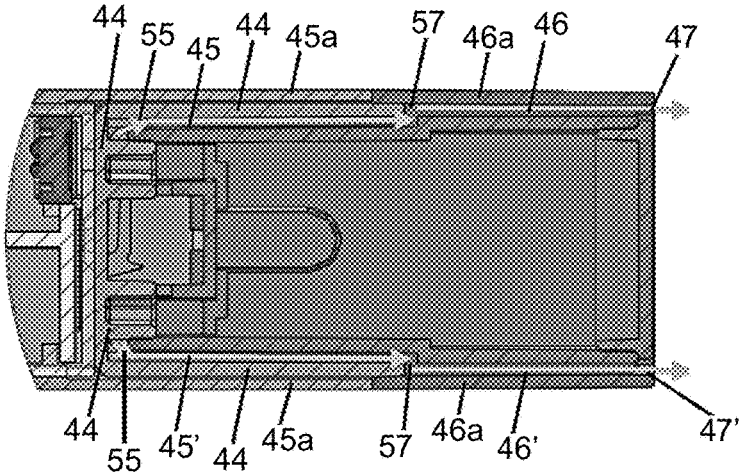

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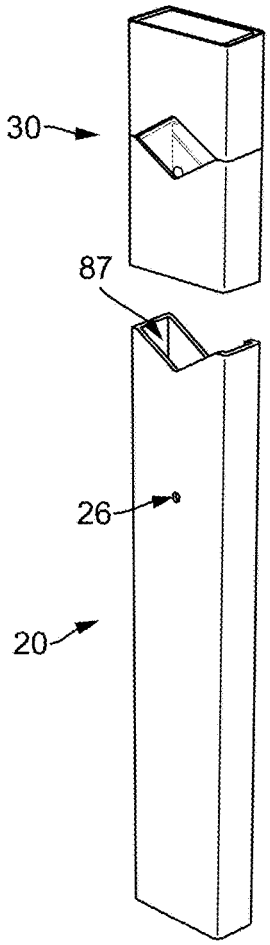

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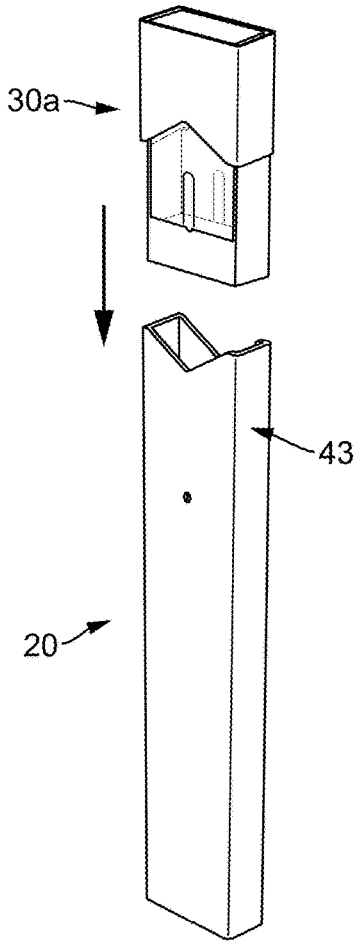

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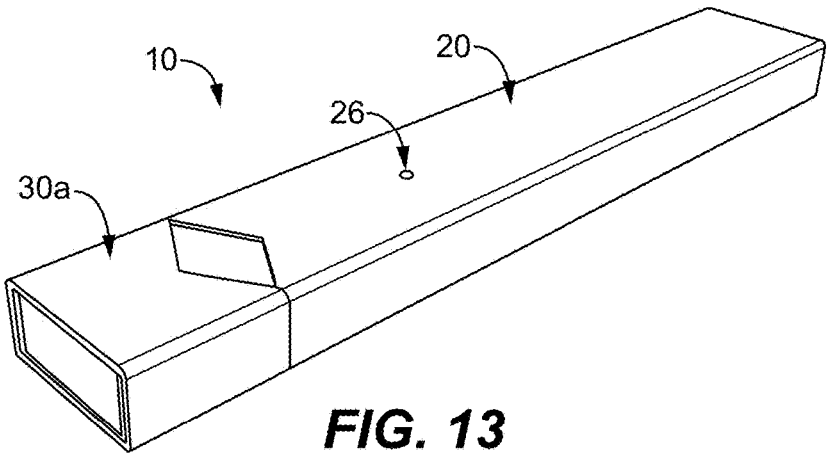
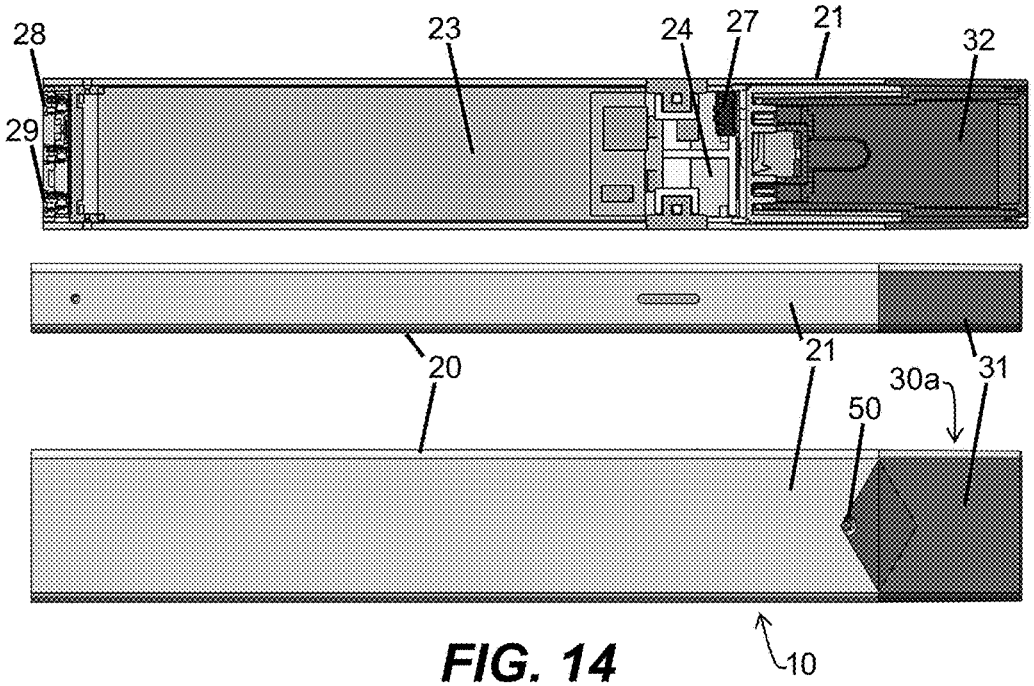


FIG. 13



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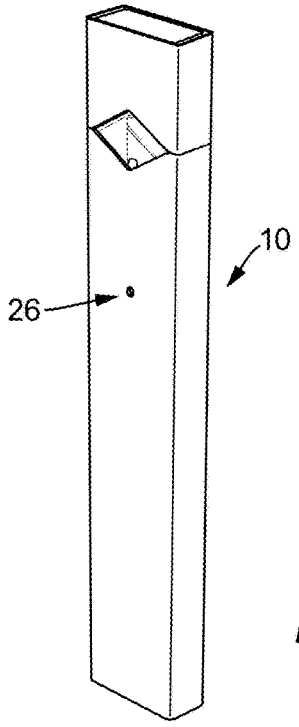


FIG. 15

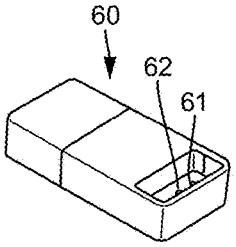


FIG. 16A

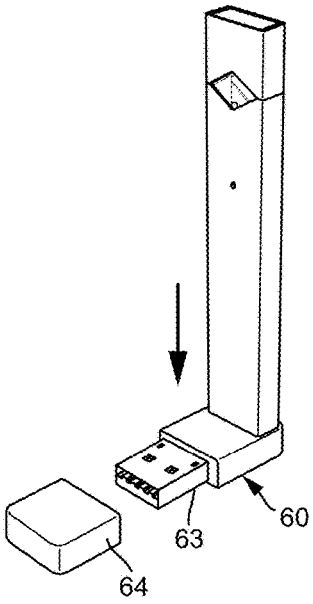
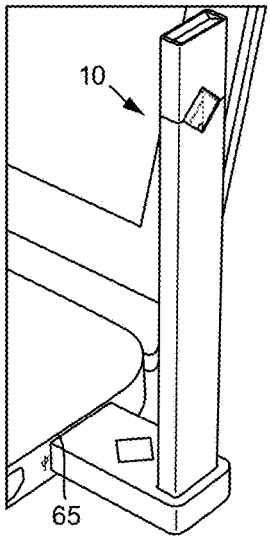


FIG. 16B



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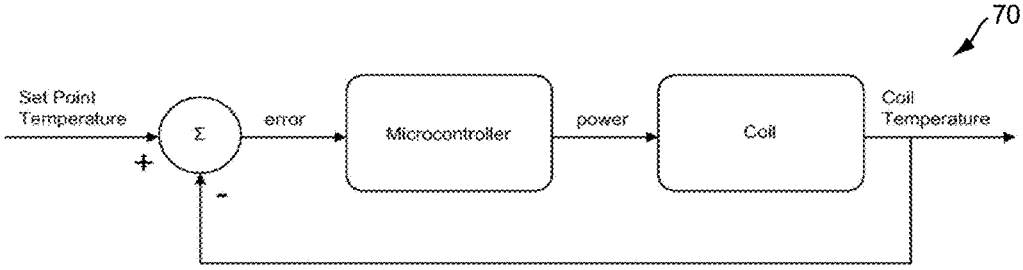

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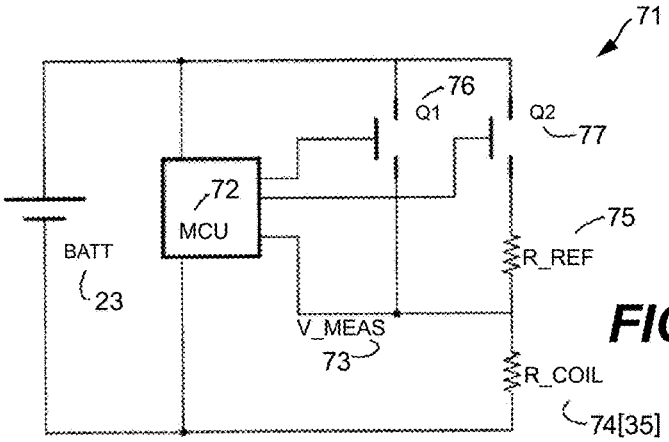
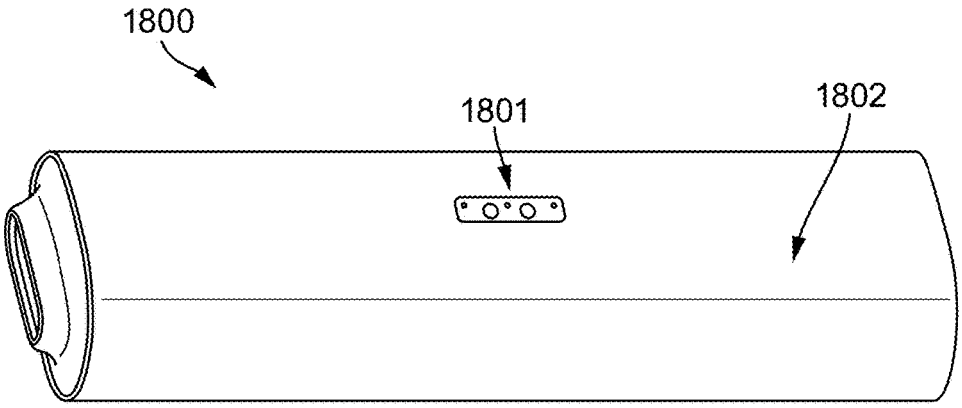


FIG. 17B



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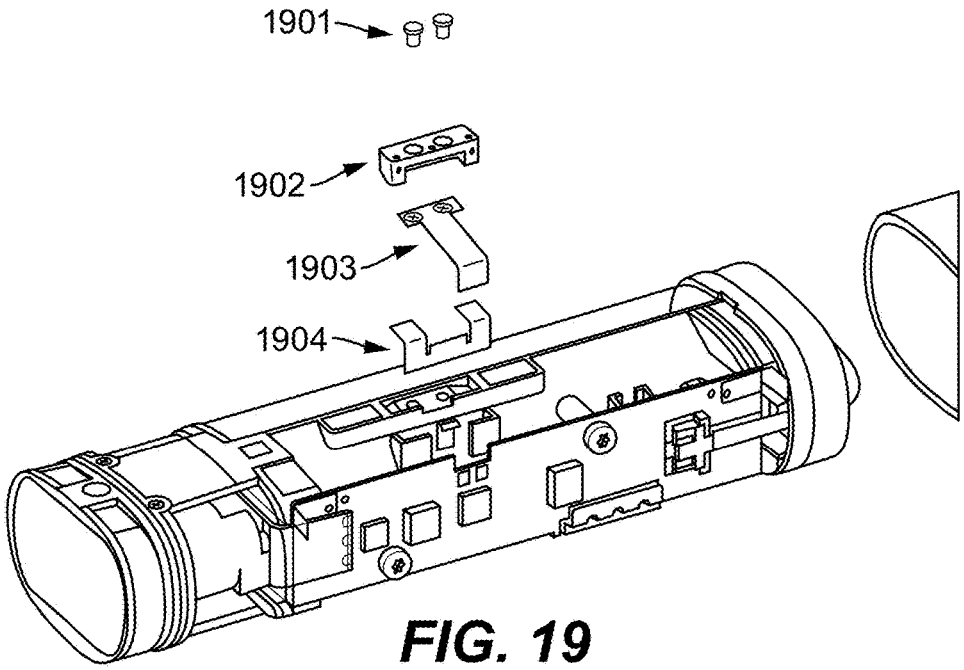

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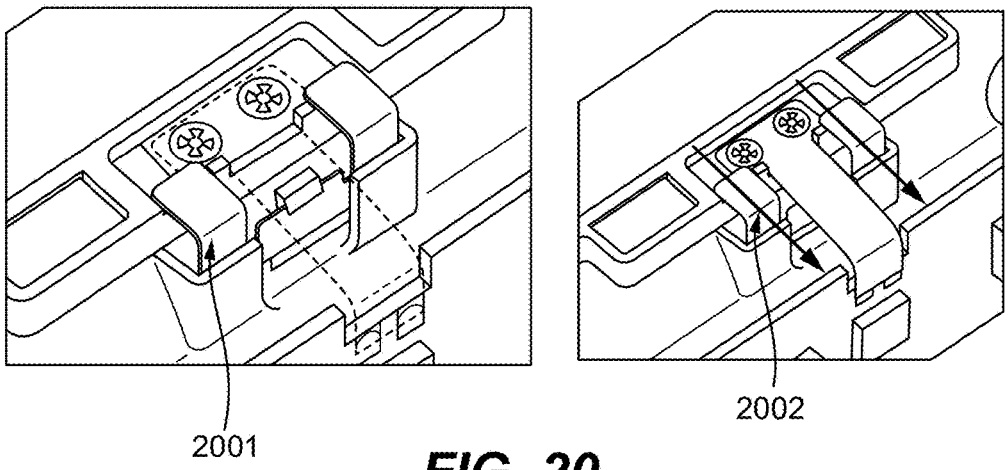

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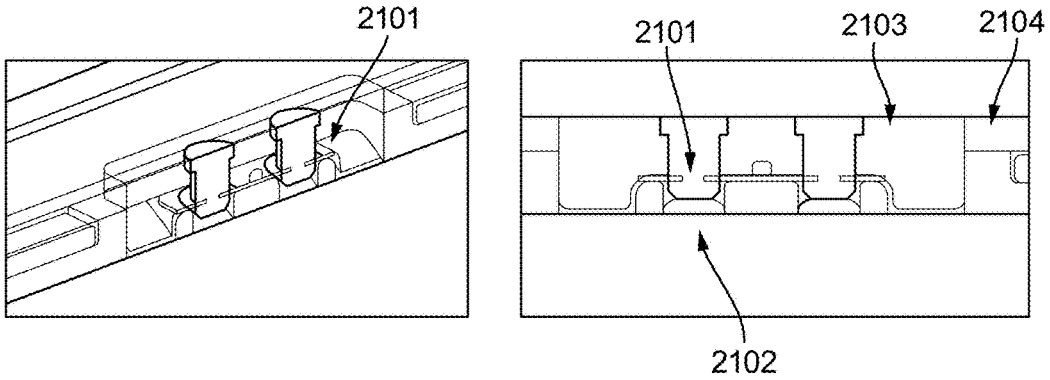

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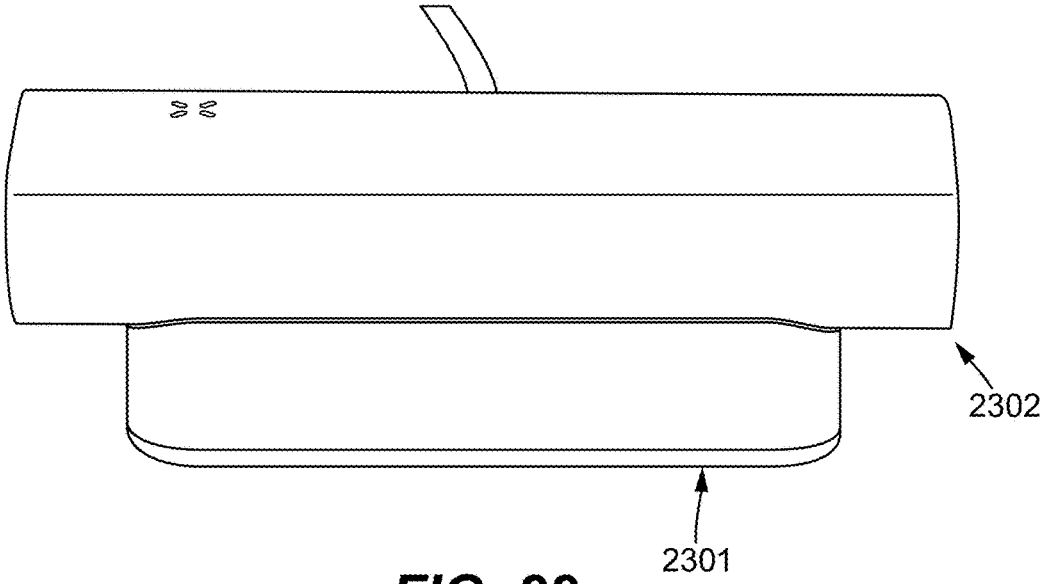

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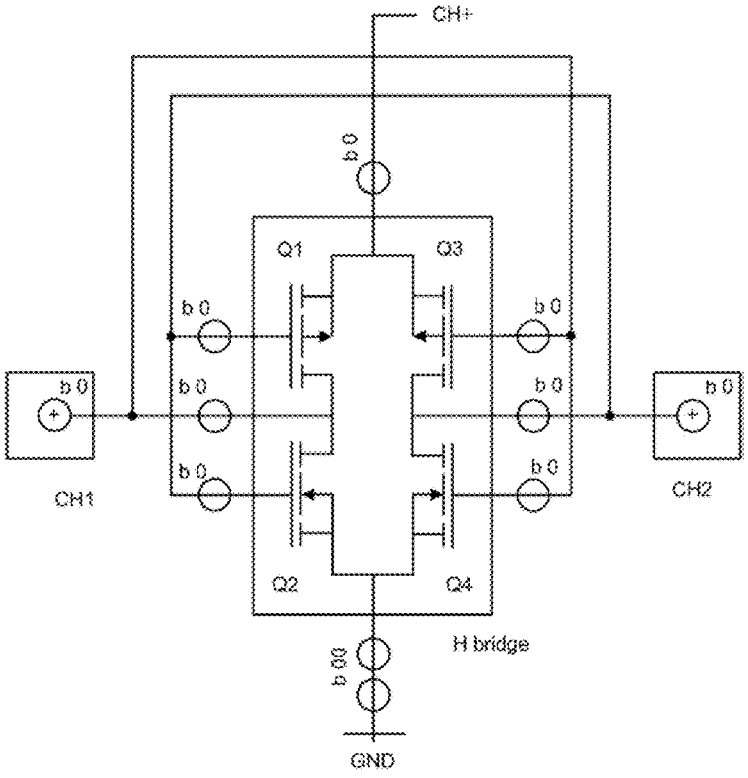

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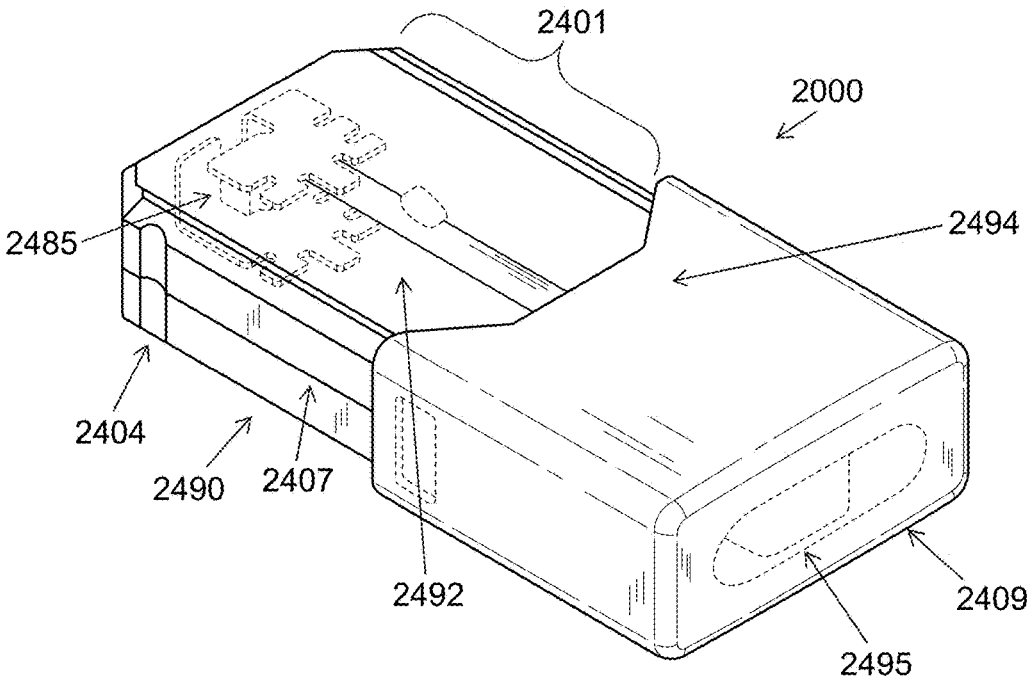

FIG. 24A

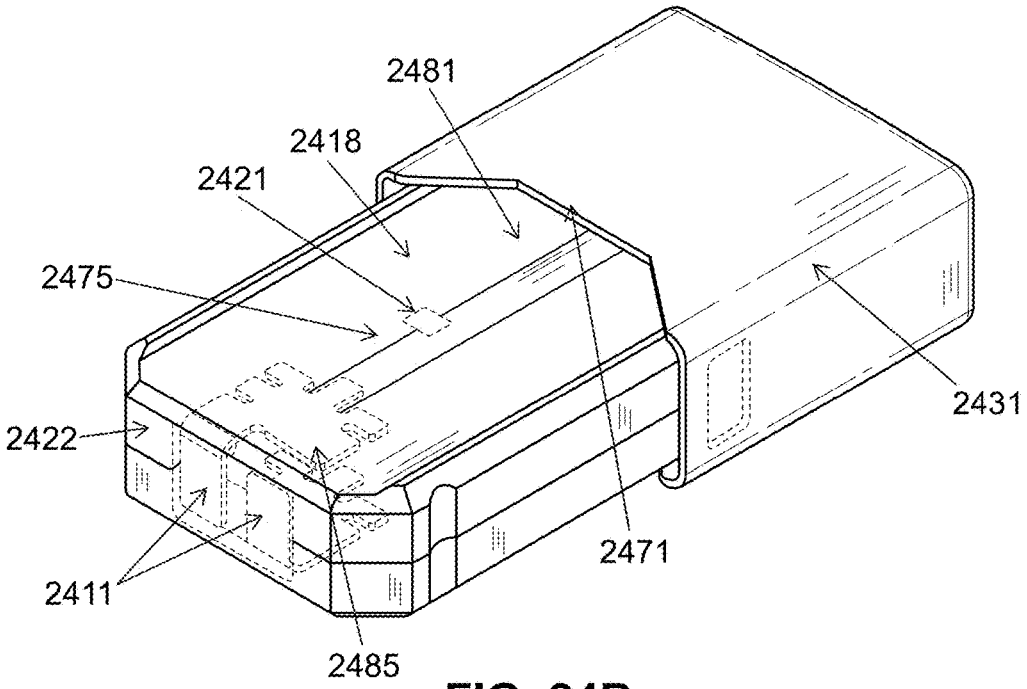

FIG. 24B

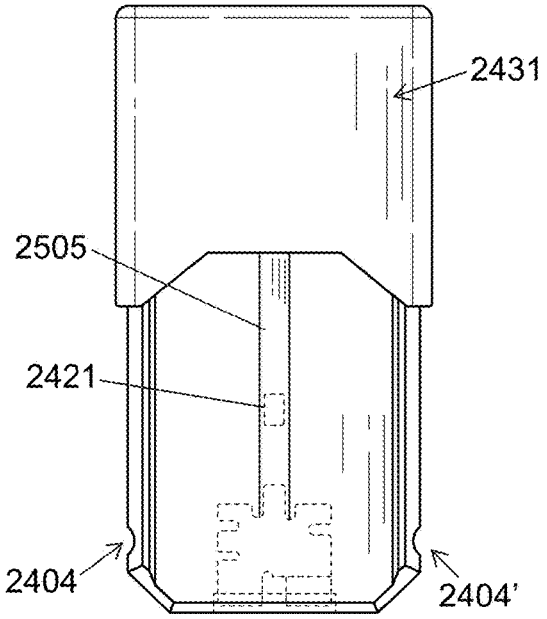

FIG. 25A

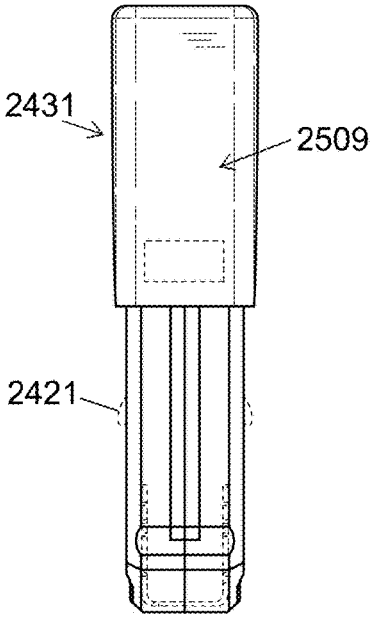

FIG. 25B

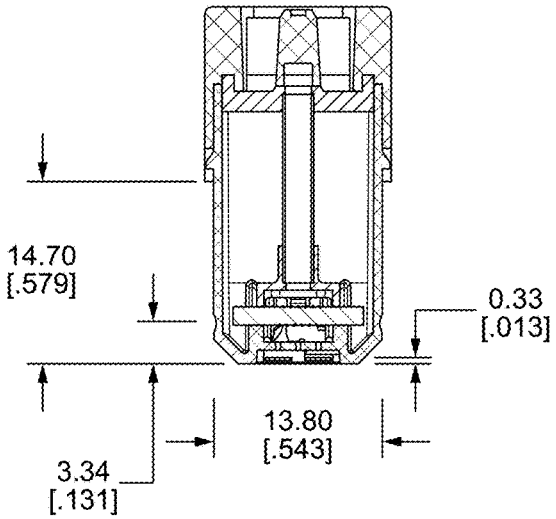

FIG. 26A

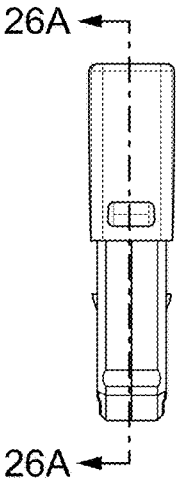

FIG. 26B

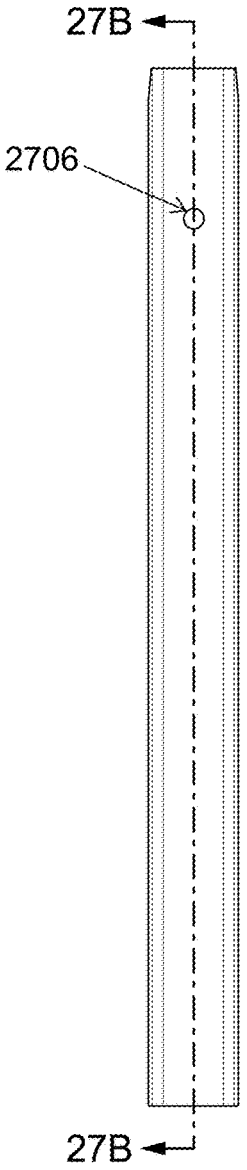

FIG. 27A

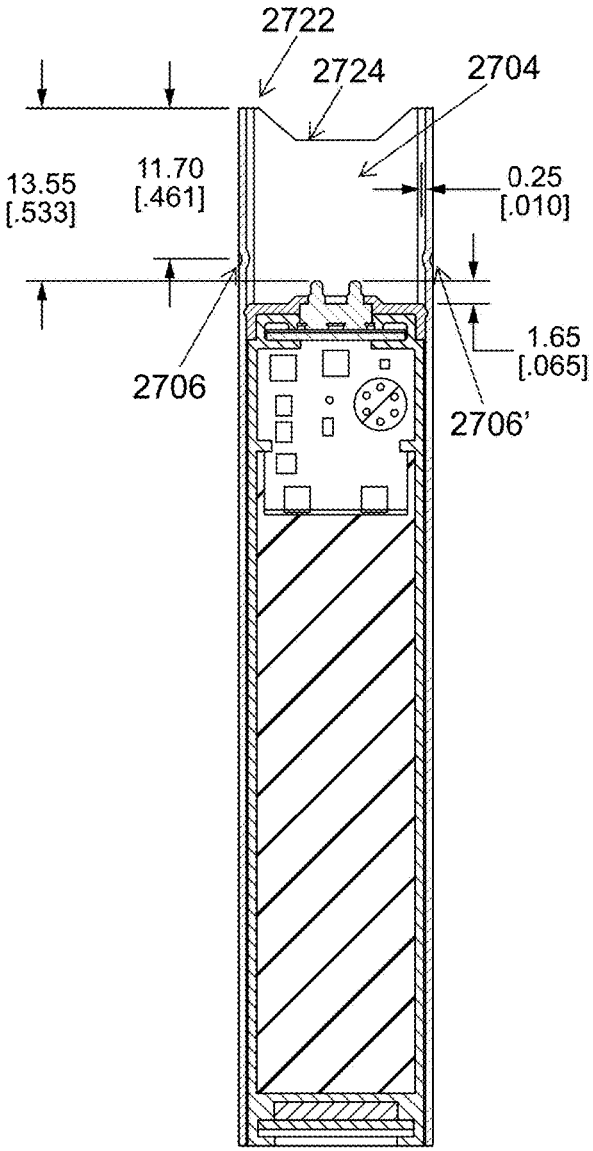

FIG. 27B

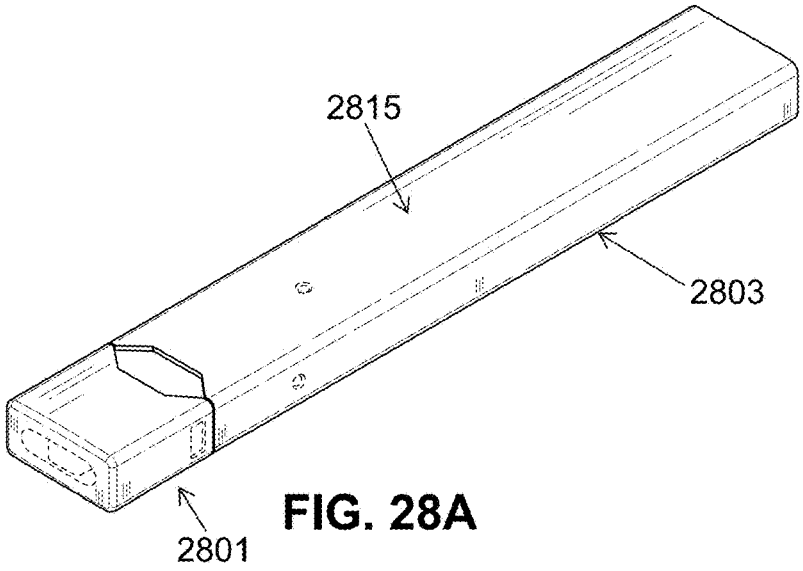

FIG. 28A

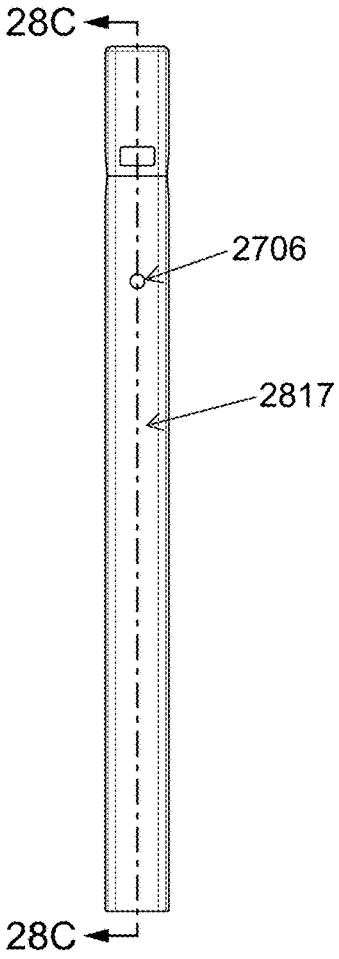

FIG. 28B

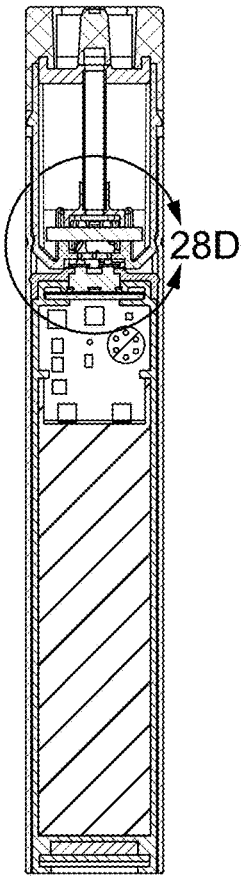

FIG. 28C

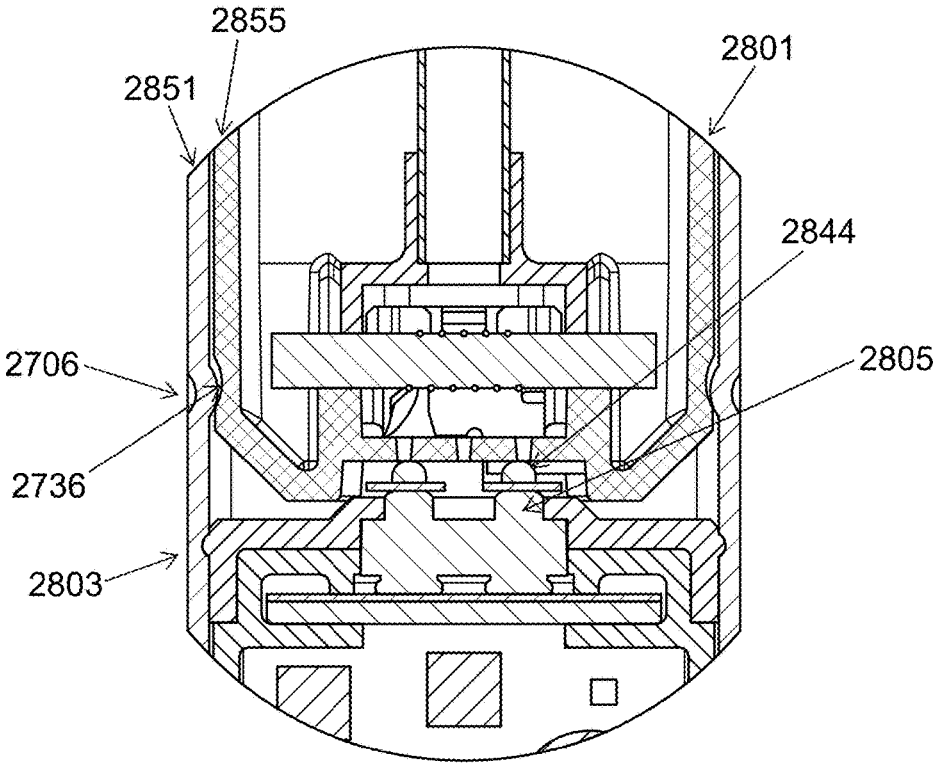

FIG. 28D

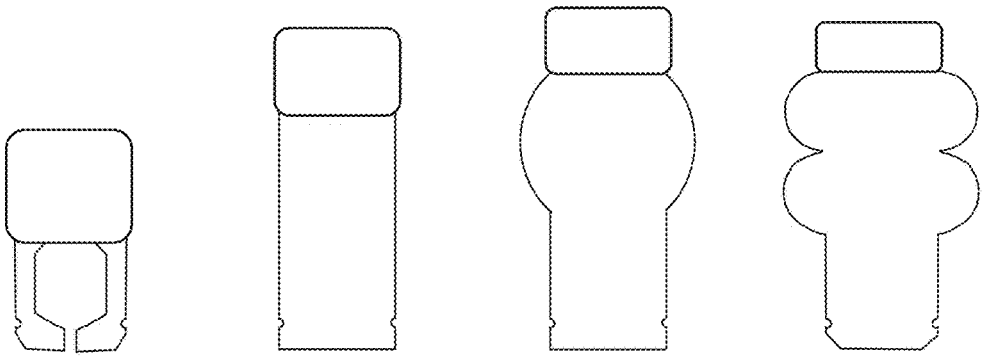

FIG. 29A FIG. 29B FIG. 29C FIG. 29D

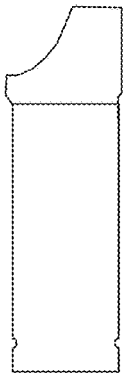

FIG. 29E

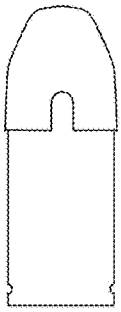

FIG. 29F

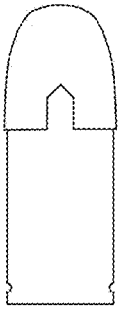

FIG. 29G

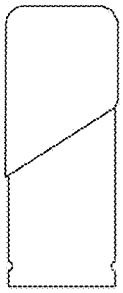

FIG. 29H

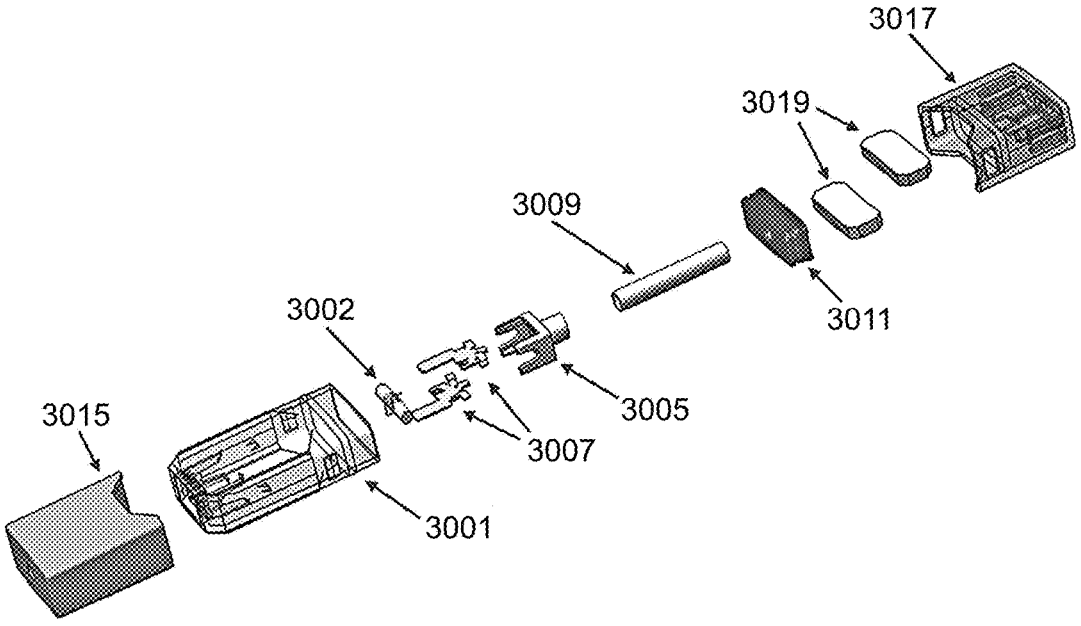

FIG. 30

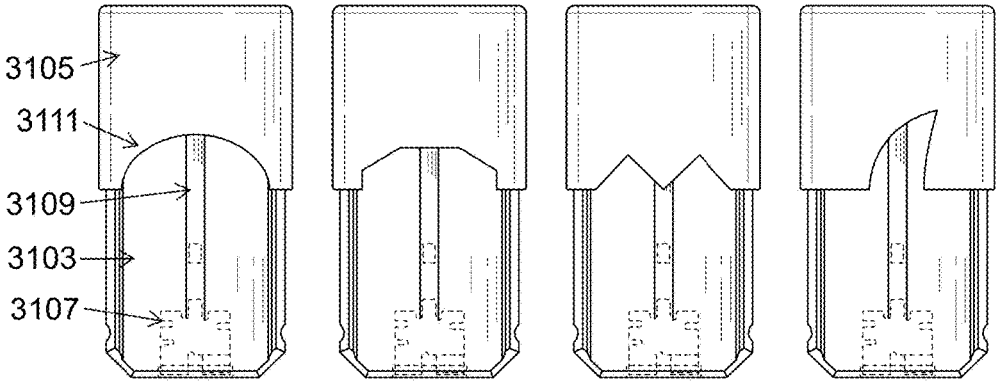

FIG. 31A FIG. 31B FIG. 31C FIG. 31D

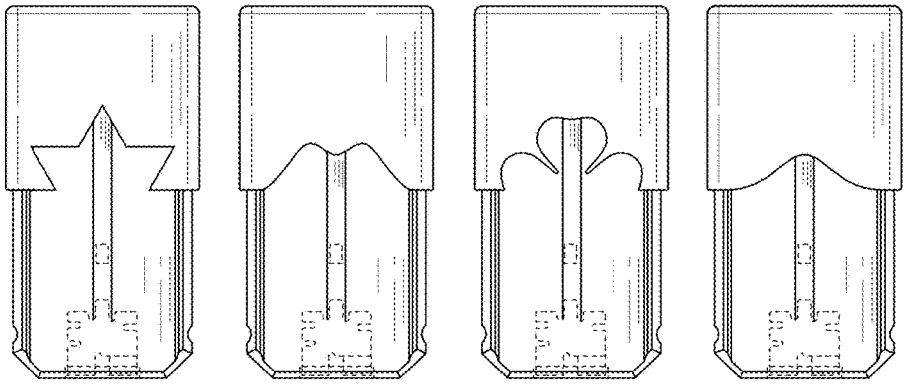

FIG. 31E FIG. 31F FIG. 31G FIG. 31H

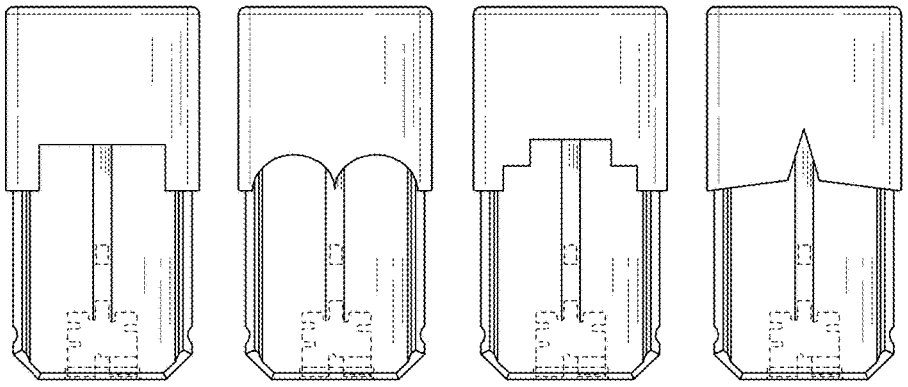

FIG. 31I FIG. 31J FIG. 31K FIG. 31L

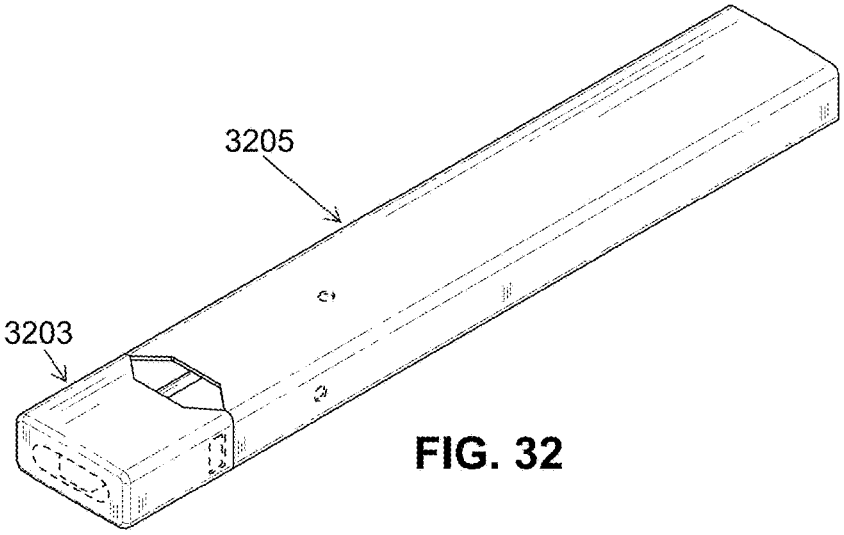

FIG. 32

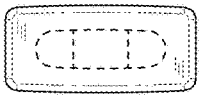

FIG. 33A

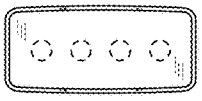

FIG. 33B

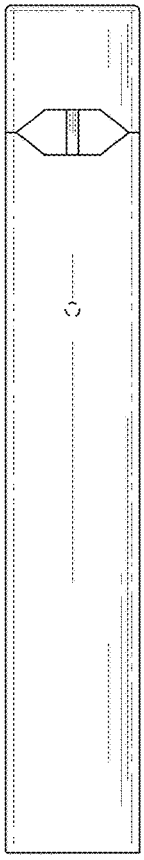

FIG. 33C

FIG. 33D

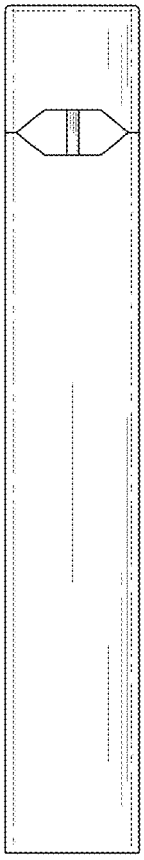

FIG. 33E

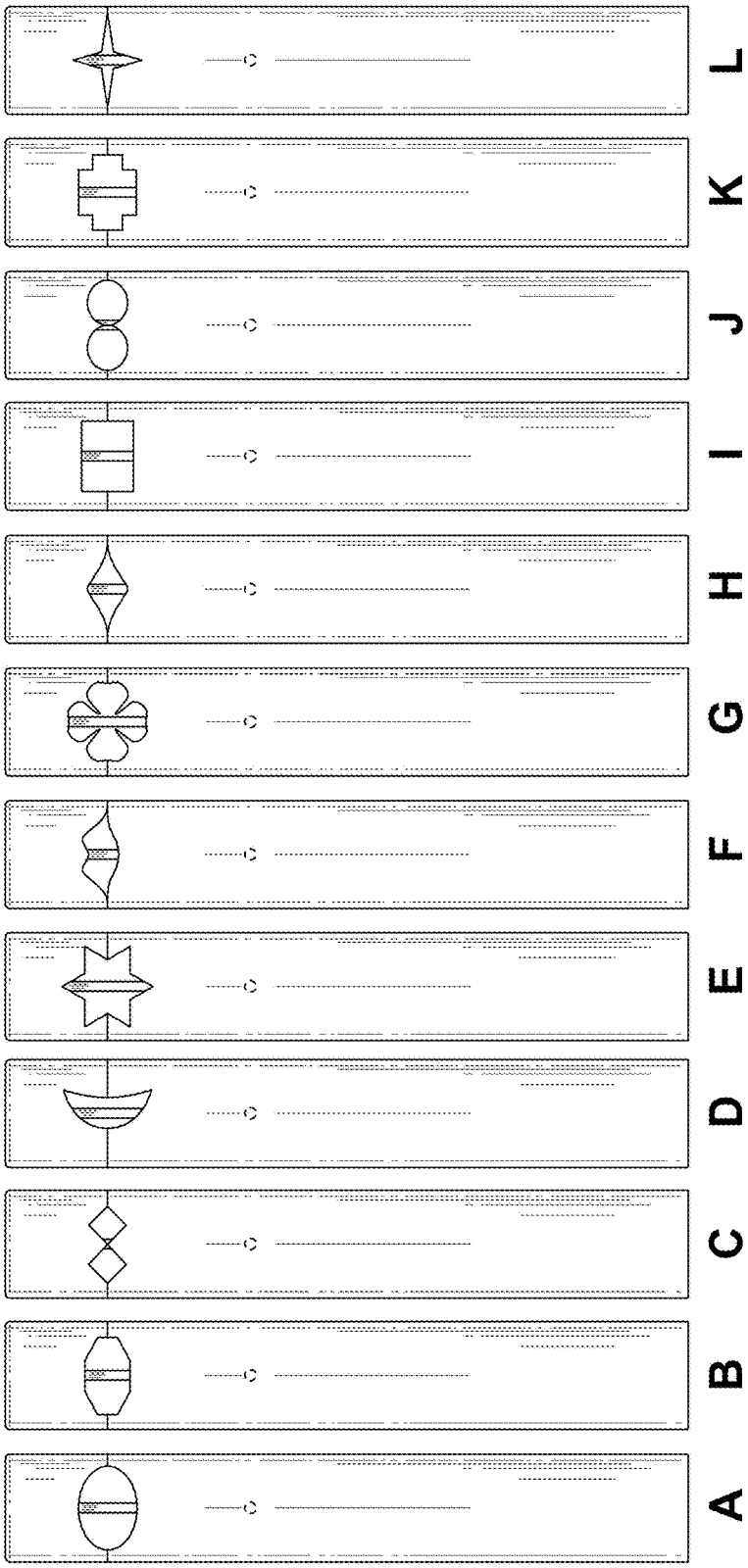

FIG. 34A-L

CARTRIDGE FOR USE WITH A VAPORIZER DEVICE

CROSS REFERENCE TO RELATED APPLICATIONS

This patent application is a continuation of U.S. patent application Ser. No. 15/257,748, filed Sep. 6, 2016 and entitled "CARTRIDGE FOR USE WITH A VAPORIZER DEVICE", which is a continuation-in-part of U.S. patent application Ser. No. 14/581,666, filed on Dec. 23, 2014, and entitled "VAPORIZATION DEVICE SYSTEMS AND METHODS", which claims priority to U.S. Provisional Patent Application No. 61/920,225, filed Dec. 23, 2013, U.S. Provisional Patent Application No. 61/936,593, filed Feb. 6, 2014, and U.S. Provisional Patent Application Ser. No. 61/937,755 filed Feb. 10, 2014. U.S. patent application Ser. No. 15/257,748 also claims priority to U.S. provisional patent application 62/294,285, filed on Feb. 11, 2016 and entitled "FILLABLE ELECTRONIC CIGARETTE CARTRIDGE AND METHOD OF FILLING", U.S. provisional patent application 62/294,281, filed on Feb. 11, 2016 and entitled "SECURELY ATTACHING CARTRIDGES FOR VAPORIZER DEVICES", International Design application No. 35/001,169, filed on Mar. 11, 2016 and entitled "ELECTRONIC VAPORIZERS WITH CARTRIDGES", and International Design application No. 35/001,170, filed on Mar. 11, 2016 and entitled "CARTRIDGES FOR AN ELECTRONIC VAPORIZER". The disclosures of each of the above-identified applications are incorporated herein by reference in their entirety.

INCORPORATION BY REFERENCE

All publications and patent applications mentioned in this specification are herein incorporated by reference in their entirety to the same extent as if each individual publication or patent application was specifically and individually indicated to be incorporated by reference.

FIELD

Described herein are vaporizer apparatuses including cartridges and vaporizers (e.g., electronic inhalable aerosol devices or electronic vaping devices). In particular, described herein are compact cartridges that can be quickly and releasably secured into a vaporizer (also referred to herein as an electronic aerosol device), while containing a substantial amount of vaporizable material, allow sufficient cooling of the vapor and easily permit a user to accurately visually confirm the amount of vaporizable material within the cartridge.

BACKGROUND

Electronic cigarettes are typically battery-powered vaporizers that may be use, e.g., to simulate the feeling of smoking, but without tobacco. Instead of cigarette smoke, the user inhales an aerosol, commonly called vapor, typically released by a heating element that atomizes a liquid solution (vaporizable material or solution). Typically, the user activates the e-cigarette by taking a puff or pressing a button. Some vaporizers look like traditional cigarettes, but they come in many variations. Although mimicking the cylindrical look of traditional cigarettes may have marketing advantages because of a preexisting familiarity with this shape and potentially feel of the product, the cylindrical shape may not be optimal. Other shapes, including rectangular shapes, may offer advantages including a greater volume for holding the battery and vaporizable material, as well ease in handling and manufacture.

Many of the battery-powered vaporizers described to date include a reusable batter-containing device portion that connects to one or more cartridges containing the consumable vaporizable material. As the cartridges are used up, they are removed and replaced with fresh ones. It may be particularly useful to have cartridges and apparatuses that have a non-circular cross-section to prevent rolling of the device when placed on a table or other surface. However, a number of surprising disadvantages may result in this configuration. For example the use of a cartridge at the proximal end of the device, which is also held by the users mouth, has been found to cause instability in the electrical contacts, particularly with cartridges of greater than 1 cm length. Further, there may be difficulties in determining the amount of vaporizable material within the cartridge, sufficiently cooling or otherwise processing the vapor generated by a heater located in the cartridge, and easily and quickly securing the cartridge into the vaporizer when force may be applied by a user's mouth at the proximal mouthpiece when a user holds the device either just by the mouth or using the mouth at the proximal end and a hand on the more distal body of the vaporizer.

Described herein are apparatuses and methods that may address the issues discussed above.

SUMMARY OF THE DISCLOSURE

The present invention relates generally to apparatuses, including systems and devices, for vaporizing material to form an inhalable aerosol. Specifically, these apparatuses may include vaporizers, cartridge for use with a vaporizer device, and vaporizers with cartridges.

In particular, described herein are cartridges that are configured for use with a vaporizer having a rechargeable power supply that includes a proximal cartridge-receiving opening. These cartridges are specifically adapted to be releasably but securely held within the cartridge-receiving opening (also referred to as a cartridge receptacle) of the vaporizer and may be configured to resist disruption of the electrical contact with the controller and power supply in the vaporizer even when held by the user's mouth.

Generally, the cartridges (which may also referred to as cartomizers) described herein may have a mouthpiece, a heater/vaporizer (e.g., heating element, wick), and a tank (fluid reservoir) to hold the vaporizable material (typically a nicotine solution), in which the cartridge is flattened and has a window into the tank through the mouthpiece so that the liquid level is visible; the window can be an opening through the mouthpiece or it can be a notch up into the mouthpiece. A cannula (e.g., tube) may run through the tank, and connect the heater/vaporizer to an opening in the mouthpiece.

As will be illustrated and described below, the cannula forms a passage for the vapor from the heater to the mouthpiece, and typically passes through the tank so that it is surrounded by vaporizable fluid in the tank; this may help to regulate the temperature of the vapor within the cannula, providing a substantially improved vaping experience. The cannula may be visible through the window/notch. Although having the cannula visible in the window may obscure the view into the tank, it also helps provide a visual reference for the liquid level that makes it much easier for a user to get a quick and accurate understanding of the actual level of vaporizable material within the tank.

In general, the mouthpiece may be opaque and may fit over the top/end of the transparent tank (storage compartment) and may be secured over the end of the storage compartment. This may allow the mouthpiece to form a lip or rim formed by the distal edge of the mouthpiece over the storage compartment that helps guide and helps secure the cartridge in the cartridge receptacle of the vaporizer.

As mentioned, the (typically opaque) mouthpiece may also or alternatively have a cut-out region on the distal edge that is cut into a shape that may form a window into the tank to show the cartridge and fluid; the cut-out region may be any appropriate shape (e.g., square, rectangular, oval, semi-circular, or combinations thereof), and may match with another cut-out region on the upper edge (proximal edge) of the cartridge receptacle of the vaporizer.

Any of these cartridges may also include a gap on the side of the cartridge to mate with a detent on the vaporizer. The gap (also referred to herein as a locking gap) may be a channel, pit, hole, divot, etc. in the sides of the elongate and flattened storage compartment. These gaps may act as a mechanical lock to secure the cartridge in the vaporizer, and may also provide tactile and/or audible \feedback (producing a click or snap) when the cartridge is properly seated in the cartridge receptacle so that there is a robust mechanical and electrical connection between the cartridge and the vaporizer.

In general, the apparatuses described herein also include vaporizers and cartridges in which the cartridge is inserted into a cartridge receptacle at the proximal end of the vaporizer so that the mouthpiece projects out of the proximal end. Overall, the combined cartridge and vaporizer may have an elongate, flattened shape that prevents rolling when the apparatus is placed on a table or other flat surface so that is lying flat on the surface. As mentioned, the body of the vaporizer, and particularly the proximal edge of the cartridge receptacle, may include a notch or cut-out portion that forms a window into the (transparent) cartridge when the cartridge is held within the cartridge receptacle. Similarly, the cartridge receptacle portion of the vaporizer may include a coupling to secure the cartridge within the cartridge receptacle even when it projects out of the end of the vaporizer, and even when the entire apparatus is held within a user's mouth only at the mouthpiece of the cartridge. Although the majority of the weight of the apparatus is in the vaporizers (near the distal end of the apparatus), the coupling, which may be two or more detents on the side of the cartridge receptacle and/or a magnetic coupling, may hold the cartridge secured in position even where the electrical coupling is a biased connection (such as a pogo pin) that would tend to push the cartridge out of the cartridge receptacle.

For example, described herein are cartridges for use with a vaporizer device, the cartridge comprising: an elongate and flattened storage compartment configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment, further wherein the storage compartment comprises a distal end and a proximal end, and a first side extending between the distal end and the proximal end; an opaque mouthpiece that is secured over the proximal end of the storage compartment, the opaque mouthpiece having a front side adjacent to the first side of the storage compartment, wherein a distal end of the opaque mouthpiece terminates in a distal edge that extends only partially between the distal end and the proximal end of the storage compartment; an opening through the opaque mouthpiece at a proximal end of the opaque mouthpiece; a notch in the front side of the mouthpiece extending from the distal edge of the opaque mouthpiece toward the proximal end of the mouthpiece, wherein the notch exposes a region of the storage compartment beneath the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and a cannula within the storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula when the storage compartment is filled with liquid vaporizable material, wherein the cannula is visible through the notch, further wherein the cannula forms a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled.

Also described herein are cartridges for use with a vaporizer device, the cartridge comprising: an elongate and flattened storage compartment configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment, further wherein the storage compartment comprises a distal end and a proximal end, and a first side extending between the distal end and the proximal end; an opaque mouthpiece that is secured over the proximal end of the storage compartment, the opaque mouthpiece having a front side adjacent to the first side of the storage compartment, wherein a distal end of the opaque mouthpiece terminates in a distal edge that extends only partially between the distal end and the proximal end of the storage compartment; an opening through the opaque mouthpiece at a proximal end of the opaque mouthpiece; a window in the front side of the mouthpiece, wherein the window exposes a region of the storage compartment beneath the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and a cannula within the storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula when the storage compartment is filled with liquid vaporizable material, wherein the cannula is visible through the window, further wherein the cannula forms a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled.

A cartridge for use with a vaporizer device may also include: an elongate and flattened storage compartment holding a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment, further wherein the storage compartment comprises a distal end and a proximal end, and a first side extending between the distal end and the proximal end; an opaque mouthpiece that is snap-fit over the proximal end of the storage compartment, the opaque mouthpiece having a front side adjacent to the first side of the storage compartment, wherein a distal end of the opaque mouthpiece terminates in a distal edge that extends midway between the distal end and the proximal end of the storage compartment; an opening through the opaque mouthpiece at a proximal end of the opaque mouthpiece; a notch in the front side of the mouthpiece extending from the distal edge of the opaque mouthpiece toward the proximal end of the mouthpiece, wherein the notch exposes a region of the storage compartment beneath the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a

resistive heating element in thermal contact with the wick; a cannula or channel within the storage compartment extending from the heater to the proximal end of the storage compartment, wherein the liquid vaporizable material is visible through the notch, further wherein the cannula or channel forms a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled; and a pair of locking gaps on lateral sides of the cartridge that are configured to engage with a pair of locking detents on the vaporizer device to secure the cartridge in the vaporizer device.

In any of the cartridge described herein, the opaque mouthpiece may be secured over the proximal end of the storage compartment by a snap-fit.

In general, the storage compartment may be filled with the liquid vaporizable material. Any liquid vaporizable material may be used, including nicotine solutions, cannaboid solutions, solutions without any active ingredient, or other vaporizable solutions.

In general, as will be described in greater detail herein, the cartridges may include a pair of electrical contacts at a distal end of the cartridge. In some variations, the electrical contacts are configured to mate with connectors (e.g., pogo pin connectors) within the cartridge receptacle of the vaporizer.

The window (e.g., notch) in the cartridge through the mouthpiece may be a rectangular, triangular, semi-circular, or oval cutout region, or some combination of these. In general, the fluid within the elongate and flattened storage compartment may be visible; for example, the elongate fluid storage compartment may be transparent or translucent.

In any of the cartridges described herein, the cartridge (e.g., the elongate fluid storage compartment) may include a pair of locking gaps on lateral sides of the cartridge that are configured to engage with a pair of locking detents on the vaporizer device to secure the cartridge in the vaporizer device.

A vaporizer device may include: a cartridge, comprising: a non-opaque storage compartment holding a liquid vaporizable material; a mouthpiece overlapping a proximal end of the non-opaque storage compartment; and a heater at a distal end of the non-opaque storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and an elongate body configured to removably attach to the cartridge, the elongate body comprising a power source configured to provide power to the heater; and a notch in a proximal end of the elongate body or a distal end of the mouthpiece, the notch configured such that the non-opaque storage compartment of the cartridge is exposed therethrough when the cartridge is attached to the elongate body.

For example, a vaporizer device may include: a cartridge, comprising: a storage compartment holding a liquid vaporizable material; a mouthpiece overlapping a proximal end of the storage compartment; and a heater at a proximal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and an elongate body configured to removably attach to the cartridge, the elongate body comprising a power source configured to provide power to the heater; wherein an air inlet is formed between the cartridge and the elongate body when the cartridge is attached to the elongate body such that an air path is formed from the air inlet, over the wick, and out the mouthpiece.

For example, a cartridge for use with a vaporizer device may include: a storage compartment holding a liquid vaporizable material; a mouthpiece overlapping a proximal end of the storage compartment; a notch in a front side of the mouthpiece extending from a distal end of the mouthpiece toward a proximal end of the mouthpiece; and a heater at a proximal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick, wherein the notch is configured to form an air inlet between the cartridge and the vaporizer device when the cartridge is attached to the vaporizer device such that an air path is formed from the air inlet, over the wick, and out the mouthpiece.

Also described herein are apparatuses including vaporizer apparatuses that include both the cartridge and the vaporizer into which the cartridge may be inserted, e.g., into a cartridge receptacle that holds the cartridge so that it extends from one end of the vaporizer.

For example a vaporizer apparatus may include: a cartridge having: an elongate and flattened storage compartment configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment and wherein the storage compartment comprises a distal end and a proximal end; a mouthpiece at the proximal end of the storage compartment; an opening through the mouthpiece at a proximal end of the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and a vaporizer, the vaporizer having: an elongate, flattened and opaque body having a distal end and a proximal end and a front side, a back side and a pair of lateral sides extending between the distal and proximal ends, wherein the elongate, flattened and opaque body is prevented from rolling when placed on a flat surface because the diameter of the front and back sides are larger than the diameter of the pair of lateral sides; a cartridge receptacle formed at the proximal end of the elongate, flattened and opaque body, wherein the cartridge receptacle has a proximal-facing opening into the proximal end of the elongate, flattened and opaque body, further wherein the cartridge receptacle comprises a proximal edge around the distal-facing opening; wherein the proximal edge of the cartridge receptacle forms a notch in the front side of the elongate, flattened and opaque body extending towards the distal end of the elongate, flattened and opaque body so that a portion of the storage compartment is visible through the notch when the cartridge is housed within the cartridge receptacle; a pair of electrical contacts in a distal surface within the cartridge receptacle configured to connect to electrical contacts on the cartridge when the cartridge is housed within the cartridge receptacle; and a detent on each of the pair of lateral sides, wherein the detents project into the cartridge receptacle and each engage a mating region on the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle.

A vaporizer apparatus may include: a cartridge having: an elongate and flattened storage compartment configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment and wherein the storage compartment comprises a distal end and a proximal end; a mouthpiece at the proximal end of the storage compartment; an opening through the mouthpiece at a proximal end of the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a

heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; a cannula within the storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula when the storage compartment is filled with liquid vaporizable material, further wherein the cannula forms a fluid connection between the heating chamber and the opening through the mouthpiece from which vaporized liquid vaporizable material may be inhaled; and a vaporizer, the vaporizer having: an elongate, flattened and opaque body having a distal end and a proximal end and a front side, a back side and opposite lateral sides extending between the distal and proximal ends, wherein the elongate, flattened and opaque body is prevented from rolling when placed on a flat surface because the diameter of the front and back sides are larger than the diameter of the opposite lateral sides; a cartridge receptacle formed at the proximal end of the elongate, flattened and opaque body, wherein the cartridge receptacle has a proximal-facing opening into the proximal end of the elongate, flattened and opaque body, further wherein the cartridge receptacle comprises a proximal edge around the proximal-facing opening; wherein the proximal edge of the cartridge receptacle forms a notch in the front side of the elongate, flattened and opaque body extending towards the distal end of the elongate, flattened and opaque body so that a portion of the storage compartment and the cannula within the storage compartment are visible through the notch when the cartridge is housed within the cartridge receptacle; a pair of electrical contacts in a distal surface within the cartridge receptacle configured to connect to electrical contacts on the cartridge when the cartridge is housed within the cartridge receptacle; and a detent on each of the opposite lateral sides, wherein the detents project into the cartridge receptacle and each engage a mating region on the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle.

For example, a vaporizer apparatus may include a cartridge having: an elongate and flattened storage compartment holding a liquid vaporizable material that is visible through the storage compartment, wherein the storage compartment comprises a distal end and a proximal end, and a first side extending between the distal end and the proximal end; a mouthpiece at the proximal end of the storage compartment, wherein the mouthpiece comprises an opaque cover that is secured over the proximal end of the storage compartment, the opaque mouthpiece having a front side adjacent to the first side of the storage compartment, wherein a distal end of the opaque cover terminates in a distal edge that extends around a perimeter of the storage compartment from a position only partially between the distal end and the proximal end of the storage compartment of the opaque cover; a cartridge notch in the front side of the mouthpiece extending from the distal edge of the opaque cover towards the proximal end of the mouthpiece, wherein the cartridge notch exposes a region of the storage compartment beneath the mouthpiece; an opening through the mouthpiece at a distal end of the mouthpiece; a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; a cannula within the storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula, further wherein the cannula forms a fluid connection between the heating chamber and the opening through the mouthpiece from which vaporized liquid vaporizable material may be inhaled, wherein the cannula is visible through the cartridge notch; and a vaporizer, the vaporizer having: an elongate, flattened and opaque body having a distal end and a proximal end and a front side, a back side and opposite lateral sides extending between the distal and proximal ends, wherein the elongate, flattened and opaque body is prevented from rolling when placed on a flat surface because the diameter of the front and back sides are larger than the diameter of the opposite lateral sides; a cartridge receptacle formed at the proximal end of the elongate, flattened and opaque body, wherein the cartridge receptacle has a proximal-facing opening into the proximal end of the elongate, flattened and opaque body, further wherein the cartridge receptacle comprises a proximal edge around the distal-facing opening; wherein the proximal edge of the cartridge receptacle forms a notch in the front side of the elongate, flattened and opaque body extending towards the distal end of the elongate, flattened and opaque body so that a portion of the storage compartment and the cannula are visible through the notch when the cartridge is housed within the cartridge receptacle; a pair of electrical contacts in a distal surface within the cartridge receptacle configured to connect to electrical contacts on the cartridge when the cartridge is housed within the cartridge receptacle; and a detent on each of the opposite lateral sides, wherein the detents project into the cartridge receptacle and each engage a mating region on the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle, wherein the cartridge notch aligns with the notch formed in the proximal edge of the cartridge receptacle when the cartridge is housed within the cartridge receptacle.

As mentioned above, in any of the cartridges described herein, the cannula may be visible within the storage compartment is visible through the notch when the cartridge is housed within the cartridge receptacle.

In any of the cartridges described herein, the elongate, flattened and opaque body may have a cross-section such that the apparatus (including the cartridge) lies flat and does not roll, when placed on a table. For example, the cartridge may have a rectangular cross-section (e.g., through the long axis, distal-to-proximal, of the cartridge); in some variations the cross-section is oval, square, etc.

In any of the devices described here, the cartridge may couple with the vaporizer using a connector that is snap fit, or other mechanical fit that is not a threaded connection. Alternatively or additional, the connector may be magnetic.

In any of these apparatuses, the pair of electrical contacts in a proximal surface within the cartridge receptacle may comprise pogo pins or other connectors that are biased against the contact on the cartridge when the two are connected.

The mouthpiece may generally comprise an opaque cover that is secured over the proximal end of the storage compartment, the opaque cover having a front side adjacent to a first side of the storage compartment extending between the proximal and distal ends of the storage compartment, wherein a distal end of the opaque cover terminates in a distal edge that extends around a perimeter of the storage compartment from a position only partially between the distal end and the proximal end of the storage compartment.

The cartridge may further comprises a cartridge notch in the front side of the mouthpiece extending from the distal edge of the opaque cover towards the proximal end of the mouthpiece, wherein the cartridge notch exposes a region of

the storage compartment beneath the mouthpiece, further wherein the cartridge notch aligns with the notch formed in the proximal edge of the cartridge receptacle when the cartridge is housed within the cartridge receptacle.

Also described herein in particular are apparatuses (e.g., vaporizer apparatuses) in which the cartridge (including any of the cartridges described herein) are magnetically coupled to with a cartridge receptacle at a proximal end of the vaporizer body so that the proximal end (e.g., mouthpiece) of the cartridge extends proximally from out of the vaporizer body. For example, a vaporizer apparatus may include: a cartridge having: an elongate and transparent storage compartment holding a liquid vaporizable material, wherein the elongate and transparent storage compartment comprises a distal end and a proximal end; an opaque mouthpiece at the proximal end of the elongate and transparent storage compartment; a pair of electrical contacts at a distal end of the cartridge; a heater at the distal end of the elongate and transparent storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and a channel within the elongate and transparent storage compartment extending from the heater to the proximal end of the elongate and transparent storage compartment, wherein the channel is visible through the elongate and transparent storage compartment, further wherein the channel forms a fluid connection between the heating chamber and the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled; and a vaporizer, the vaporizer having: an elongate body having a distal end and a proximal end; a cartridge receptacle formed at the proximal end of the elongate body, wherein the cartridge receptacle has a proximal-facing opening into the proximal end of the elongate body, further wherein the cartridge receptacle comprises a proximal edge around the distal-facing opening; an window though a side of the cartridge receptacle so that at least a portion of the elongate and transparent storage compartment is visible through the window when the cartridge is held within the cartridge receptacle; a pair of electrical contacts in a distal surface within the cartridge receptacle configured to connect to the pair of electrical contacts at the distal end of the cartridge when the cartridge is held within the cartridge receptacle; and a first magnetic coupling configured to magnetically secure the cartridge in the cartridge receptacle; and a second magnetic coupling configured to magnetically couple the vaporizer to a charger.

For example, a vaporizer apparatus may include: a cartridge having: an elongate and transparent storage compartment holding a liquid vaporizable material, wherein the elongate and transparent storage compartment comprises a distal end and a proximal end; an opaque mouthpiece at the proximal end of the elongate and transparent storage compartment; a pair of electrical contacts at a distal end of the cartridge; a heater at the distal end of the elongate and transparent storage compartment, wherein the heater comprises a heating chamber, a wick within the heating chamber, and a resistive heating element in thermal contact with the wick; and a channel within the elongate and transparent storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the elongate and transparent storage compartment, wherein the channel is visible through the elongate and transparent storage compartment, further wherein the channel forms a fluid connection between the heating chamber and the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled; and a vaporizer, the vaporizer having: an elongate body having a distal end and a proximal end; a cartridge receptacle formed at the proximal end of the elongate body, wherein the cartridge receptacle has a proximal-facing opening into the distal end of the elongate body, further wherein the cartridge receptacle comprises a proximal edge around the distal-facing opening; an window though a side of the cartridge receptacle into the cartridge receptacle so that at least a portion of the elongate and transparent storage compartment and the channel is visible through the window when the cartridge is held within the cartridge receptacle; a pair of electrical contacts in a distal surface within the cartridge receptacle configured to connect to the pair of electrical contacts at the distal end of the cartridge when the cartridge is held within the cartridge receptacle; and a first magnetic coupling configured to magnetically secure the cartridge in the cartridge receptacle; and a second magnetic coupling at a distal end of the vaporizer configured to magnetically couple the vaporizer to a charger.

In general the notch (e.g., cut-out region) on the window in the side of the elongate and opaque body may be any appropriate shape, including a rectangular, triangular, semicircular, or oval (or any combination of these) cutout region, and the two may match or be different.

The channel within the elongate and transparent storage compartment may be visible through the window when the cartridge is housed within the cartridge receptacle.

Also described herein are cartridges in which the arrangement of contacts (e.g., between the cartridge and the vaporizer, are configured within a particular spacing regime to optimize the electrical and mechanical connection between the two, even when the cartridge is held within the user's mouth, and not supported (e.g., by a hand) at the more distal end region.

For example, described herein are cartridge devices holding a vaporizable material for securely coupling with an electronic inhalable aerosol device. A device may include: a mouthpiece; a fluid storage compartment holding a vaporizable material; a base configured to fit into a rectangular opening that is between 13-14 mm deep, 4.5-5.5 mm wide, and 13-14 mm long, the base having a bottom surface comprising a first electrical contact and a second electrical contact, a first locking gap on a first lateral surface of the base, and a second locking gap on a second lateral surface of the base that is opposite first lateral surface.

A cartridge device holding a vaporizable material for securely coupling with an electronic inhalable aerosol device may include: a mouthpiece; a fluid storage compartment holding a vaporizable material; a base configured to fit into a rectangular opening that is between 13-14 mm deep, 4.5-5.5 mm wide, and 13-14 mm long, the base having a length of at least 10 mm, and a bottom surface comprising a first electrical contact and a second electrical contact, a first locking gap on a first lateral surface of the base positioned between 3-4 mm above the bottom surface, and a second locking gap on a second lateral surface of the base that is opposite first lateral surface.

In some variations, the device may further comprise a body that comprises at least one of: a power source, a printed circuit board, a switch, and a temperature regulator. The device may further comprise a temperature regulator in communication with a temperature sensor. The temperature sensor may be the heater. The power source may be rechargeable. The power source may be removable. The oven may further comprise an access lid. The vapor forming medium may comprise tobacco. The vapor forming medium may comprise a botanical. The vapor forming medium may be heated in the oven chamber wherein the vapor forming

medium may comprise a humectant to produce the vapor, wherein the vapor comprises a gas phase humectant. The vapor may be mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of about 1 micron. The vapor forming medium may be heated in the oven chamber, wherein the vapor is mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of less than or equal to 0.9 micron. The vapor forming medium may be heated in the oven chamber, wherein the vapor is mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of less than or equal to 0.8 micron. The vapor forming medium may be heated in the oven chamber, wherein the vapor is mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of less than or equal to 0.7 micron. The vapor forming medium may be heated in the oven chamber, wherein the vapor is mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of less than or equal to 0.6 micron. The vapor forming medium may be heated in the oven chamber, wherein the vapor is mixed in the condensation chamber with air from the aeration vent to produce the inhalable aerosol comprising particle diameters of average size of less than or equal to 0.5 micron.

In some variations, the humectant may comprise glycerol as a vapor-forming medium. The humectant may comprise vegetable glycerol. The humectant may comprise propylene glycol. The humectant may comprise a ratio of vegetable glycerol to propylene glycol. The ratio may be about 100:0 vegetable glycerol to propylene glycol. The ratio may be about 90:10 vegetable glycerol to propylene glycol. The ratio may be about 80:20 vegetable glycerol to propylene glycol. The ratio may be about 70:30 vegetable glycerol to propylene glycol. The ratio may be about 60:40 vegetable glycerol to propylene glycol. The ratio may be about 50:50 vegetable glycerol to propylene glycol. The humectant may comprise a flavorant. The vapor forming medium may be heated to its pyrolytic temperature. The vapor forming medium may heated to 200° C. at most. The vapor forming medium may be heated to 160° C. at most. The inhalable aerosol may be cooled to a temperature of about 50°-70° C. at most, before exiting the aerosol outlet of the mouthpiece.

Also described herein are methods for generating an inhalable aerosol. Such a method may comprise: providing an inhalable aerosol generating device wherein the device comprises: an oven comprising an oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein; a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol; an air inlet that originates a first airflow path that includes the oven chamber; and an aeration vent that originates a second airflow path that allows air from the aeration vent to join the first airflow path prior to or within the condensation chamber and downstream from the oven chamber thereby forming a joined path, wherein the joined path is configured to deliver the inhalable aerosol formed in the condensation chamber to a user.

The oven may be within a body of the device. The device may further comprise a mouthpiece, wherein the mouthpiece comprises at least one of the air inlet, the aeration vent, and the condenser. The mouthpiece may be separable from the oven. The mouthpiece may be integral to a body of the device, wherein the body comprises the oven. The method may further comprise a body that comprises the oven, the condenser, the air inlet, and the aeration vent. The mouthpiece may be separable from the body.

The oven chamber may comprise an oven chamber inlet and an oven chamber outlet, and the oven further comprises a first valve at the oven chamber inlet, and a second valve at the oven chamber outlet.

The vapor forming medium may comprise tobacco. The vapor forming medium may comprise a botanical. The vapor forming medium may be heated in the oven chamber wherein the vapor forming medium may comprise a humectant to produce the vapor, wherein the vapor comprises a gas phase humectant. The vapor may comprise particle diameters of average mass of about 1 micron. The vapor may comprise particle diameters of average mass of about 0.9 micron. The vapor may comprise particle diameters of average mass of about 0.8 micron. The vapor may comprise particle diameters of average mass of about 0.7 micron. The vapor may comprise particle diameters of average mass of about 0.6 micron. The vapor may comprise particle diameters of average mass of about 0.5 micron.

In some variations, the humectant may comprise glycerol as a vapor-forming medium. The humectant may comprise vegetable glycerol. The humectant may comprise propylene glycol. The humectant may comprise a ratio of vegetable glycerol to propylene glycol. The ratio may be about 100:0 vegetable glycerol to propylene glycol. The ratio may be about 90:10 vegetable glycerol to propylene glycol. The ratio may be about 80:20 vegetable glycerol to propylene glycol. The ratio may be about 70:30 vegetable glycerol to propylene glycol. The ratio may be about 60:40 vegetable glycerol to propylene glycol. The ratio may be about 50:50 vegetable glycerol to propylene glycol. The humectant may comprise a flavorant. The vapor forming medium may be heated to its pyrolytic temperature. The vapor forming medium may heated to 200° C. at most. The vapor forming medium may be heated to 160° C. at most. The inhalable aerosol may be cooled to a temperature of about 50°-70° C. at most, before exiting the aerosol outlet of the mouthpiece.

The device may be user serviceable. The device may not be user serviceable.

A method for generating an inhalable aerosol may include: providing a vaporization device, wherein said device produces a vapor comprising particle diameters of average mass of about 1 micron or less, wherein said vapor is formed by heating a vapor forming medium in an oven chamber to a first temperature below the pyrolytic temperature of said vapor forming medium, and cooling said vapor in a condensation chamber to a second temperature below the first temperature, before exiting an aerosol outlet of said device.

A method of manufacturing a device for generating an inhalable aerosol may include: providing said device comprising a mouthpiece comprising an aerosol outlet at a first end of the device; an oven comprising an oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein, a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol, an air inlet that originates a first airflow path that includes the oven chamber and then the condensation chamber, an aeration vent that originates a second airflow path that joins the first airflow path prior to or within the condensation chamber after the vapor is formed in the oven chamber, wherein the joined first airflow path and second airflow path are configured to deliver the inhalable aerosol formed in the condensation chamber through the aerosol outlet of the mouthpiece to a user.

The method may further comprise providing the device comprising a power source or battery, a printed circuit board, a temperature regulator or operational switches.

A device for generating an inhalable aerosol may comprise a mouthpiece comprising an aerosol outlet at a first end of the device and an air inlet that originates a first airflow path; an oven comprising an oven chamber that is in the first airflow path and includes the oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein; a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol; and an aeration vent that originates a second airflow path that allows air from the aeration vent to join the first airflow path prior to or within the condensation chamber and downstream from the oven chamber thereby forming a joined path, wherein the joined path is configured to deliver the inhalable aerosol formed in the condensation chamber through the aerosol outlet of the mouthpiece to a user.

A device for generating an inhalable aerosol may comprise: a mouthpiece comprising an aerosol outlet at a first end of the device, an air inlet that originates a first airflow path, and an aeration vent that originates a second airflow path that allows air from the aeration vent to join the first airflow path; an oven comprising an oven chamber that is in the first airflow path and includes the oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein; and a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol and wherein air from the aeration vent joins the first airflow path prior to or within the condensation chamber and downstream from the oven chamber thereby forming a joined path, wherein the joined path is configured to deliver the inhalable aerosol through the aerosol outlet of the mouthpiece to a user.

A device for generating an inhalable aerosol may comprise: a device body comprising a cartridge receptacle; a cartridge comprising: a fluid storage compartment, and a channel integral to an exterior surface of the cartridge, and an air inlet passage formed by the channel and an internal surface of the cartridge receptacle when the cartridge is inserted into the cartridge receptacle; wherein the channel forms a first side of the air inlet passage, and an internal surface of the cartridge receptacle forms a second side of the air inlet passage.

A device for generating an inhalable aerosol may comprise: a device body comprising a cartridge receptacle; a cartridge comprising: a fluid storage compartment, and a channel integral to an exterior surface of the cartridge, and an air inlet passage formed by the channel and an internal surface of the cartridge receptacle when the cartridge is inserted into the cartridge receptacle; wherein the channel forms a first side of the air inlet passage, and an internal surface of the cartridge receptacle forms a second side of the air inlet passage.

The channel may comprise at least one of a groove, a trough, a depression, a dent, a furrow, a trench, a crease, and a gutter. The integral channel may comprise walls that are either recessed into the surface or protrude from the surface where it is formed. The internal side walls of the channel may form additional sides of the air inlet passage. The cartridge may further comprise a second air passage in fluid communication with the air inlet passage to the fluid storage compartment, wherein the second air passage is formed through the material of the cartridge. The cartridge may further comprise a heater. The heater may be attached to a first end of the cartridge.

The heater may comprise a heater chamber, a first pair of heater contacts, a fluid wick, and a resistive heating element in contact with the wick, wherein the first pair of heater contacts comprise thin plates affixed about the sides of the heater chamber, and wherein the fluid wick and resistive heating element are suspended there between. The first pair of heater contacts may further comprise a formed shape that comprises a tab having a flexible spring value that extends out of the heater to couple to complete a circuit with the device body. The first pair of heater contacts may be a heat sink that absorbs and dissipates excessive heat produced by the resistive heating element. The first pair of heater contacts may contact a heat shield that protects the heater chamber from excessive heat produced by the resistive heating element. The first pair of heater contacts may be press-fit to an attachment feature on the exterior wall of the first end of the cartridge. The heater may enclose a first end of the cartridge and a first end of the fluid storage compartment. The heater may comprise a first condensation chamber. The heater may comprise more than one first condensation chamber. The first condensation chamber may be formed along an exterior wall of the cartridge. The cartridge may further comprise a mouthpiece. The mouthpiece may be attached to a second end of the cartridge. The mouthpiece may comprise a second condensation chamber. The mouthpiece may comprise more than one second condensation chamber. The second condensation chamber may be formed along an exterior wall of the cartridge.

The cartridge may comprise a first condensation chamber and a second condensation chamber. The first condensation chamber and the second condensation chamber may be in fluid communication. The mouthpiece may comprise an aerosol outlet in fluid communication with the second condensation chamber. The mouthpiece may comprise more than one aerosol outlet in fluid communication with more than one the second condensation chamber. The mouthpiece may enclose a second end of the cartridge and a second end of the fluid storage compartment.

The device may comprise an airflow path comprising an air inlet passage, a second air passage, a heater chamber, a first condensation chamber, a second condensation chamber, and an aerosol outlet. The airflow path may comprise more than one air inlet passage, a heater chamber, more than one first condensation chamber, more than one second condensation chamber, more than one second condensation chamber, and more than one aerosol outlet. The heater may be in fluid communication with the fluid storage compartment. The fluid storage compartment may be capable of retaining condensed aerosol fluid. The condensed aerosol fluid may comprise a nicotine formulation. The condensed aerosol fluid may comprise a humectant. The humectant may comprise propylene glycol. The humectant may comprise vegetable glycerin.

The cartridge may be detachable. The cartridge may be receptacle and the detachable cartridge forms a separable coupling. The separable coupling may comprise a friction assembly, a snap-fit assembly or a magnetic assembly. The cartridge may comprise a fluid storage compartment, a heater affixed to a first end with a snap-fit coupling, and a mouthpiece affixed to a second end with a snap-fit coupling.

A device for generating an inhalable aerosol may comprise: a device body comprising a cartridge receptacle for receiving a cartridge; wherein an interior surface of the cartridge receptacle forms a first side of an air inlet passage when a cartridge comprising a channel integral to an exterior surface is inserted into the cartridge receptacle, and wherein the channel forms a second side of the air inlet passage.

A device for generating an inhalable aerosol may comprise: a device body comprising a cartridge receptacle for receiving a cartridge; wherein the cartridge receptacle comprises a channel integral to an interior surface and forms a first side of an air inlet passage when a cartridge is inserted into the cartridge receptacle, and wherein an exterior surface of the cartridge forms a second side of the air inlet passage.

A cartridge for a device for generating an inhalable aerosol may include: a fluid storage compartment; a channel integral to an exterior surface, wherein the channel forms a first side of an air inlet passage; and wherein an internal surface of a cartridge receptacle in the device forms a second side of the air inlet passage when the cartridge is inserted into the cartridge receptacle.

A cartridge for a device for generating an inhalable aerosol may comprise: a fluid storage compartment, wherein an exterior surface of the cartridge forms a first side of an air inlet channel when inserted into a device body comprising a cartridge receptacle, and wherein the cartridge receptacle further comprises a channel integral to an interior surface, and wherein the channel forms a second side of the air inlet passage.

The cartridge may further comprise a second air passage in fluid communication with the channel, wherein the second air passage is formed through the material of the cartridge from an exterior surface of the cartridge to the fluid storage compartment.

The cartridge may comprise at least one of: a groove, a trough, a depression, a dent, a furrow, a trench, a crease, and a gutter. The integral channel may comprise walls that are either recessed into the surface or protrude from the surface where it is formed. The internal side walls of the channel may form additional sides of the air inlet passage.

A device for generating an inhalable aerosol may comprise: a cartridge comprising; a fluid storage compartment; a heater affixed to a first end comprising; a first heater contact, a resistive heating element affixed to the first heater contact; a device body comprising; a cartridge receptacle for receiving the cartridge; a second heater contact adapted to receive the first heater contact and to complete a circuit; a power source connected to the second heater contact; a printed circuit board (PCB) connected to the power source and the second heater contact; wherein the PCB is configured to detect the absence of fluid based on the measured resistance of the resistive heating element, and turn off the device.

The printed circuit board (PCB) may comprise a microcontroller; switches; circuitry comprising a reference resister; and an algorithm comprising logic for control parameters; wherein the microcontroller cycles the switches at fixed intervals to measure the resistance of the resistive heating element relative to the reference resistor, and applies the algorithm control parameters to control the temperature of the resistive heating element.

The micro-controller may instruct the device to turn itself off when the resistance exceeds the control parameter threshold indicating that the resistive heating element is dry.

A cartridge for a device for generating an inhalable aerosol may comprise: a fluid storage compartment; a heater affixed to a first end comprising: a heater chamber, a first pair of heater contacts, a fluid wick, and a resistive heating element in contact with the wick; wherein the first pair of heater contacts comprise thin plates affixed about the sides of the heater chamber, and wherein the fluid wick and resistive heating element are suspended there between.

The first pair of heater contacts may further comprise: a formed shape that comprises a tab having a flexible spring value that extends out of the heater to complete a circuit with the device body. The heater contacts may be configured to mate with a second pair of heater contacts in a cartridge receptacle of the device body to complete a circuit. The first pair of heater contacts may also be a heat sink that absorbs and dissipates excessive heat produced by the resistive heating element. The first pair of heater contacts may be a heat shield that protect the heater chamber from excessive heat produced by the resistive heating element.

A cartridge for a device for generating an inhalable aerosol may comprise: a heater comprising; a heater chamber, a pair of thin plate heater contacts therein, a fluid wick positioned between the heater contacts, and a resistive heating element in contact with the wick; wherein the heater contacts each comprise a fixation site wherein the resistive heating element is tensioned therebetween.

A cartridge for a device for generating an inhalable aerosol may comprise a heater, wherein the heater is attached to a first end of the cartridge.

The heater may enclose a first end of the cartridge and a first end of the fluid storage compartment. The heater may comprise more than one first condensation chamber. The heater may comprise a first condensation chamber. The condensation chamber may be formed along an exterior wall of the cartridge.

A cartridge for a device for generating an inhalable aerosol may comprise a fluid storage compartment; and a mouthpiece, wherein the mouthpiece is attached to a second end of the cartridge.

The mouthpiece may enclose a second end of the cartridge and a second end of the fluid storage compartment. The mouthpiece may comprise a second condensation chamber. The mouthpiece may comprise more than one second condensation chamber. The second condensation chamber may be formed along an exterior wall of the cartridge.

A cartridge for a device for generating an inhalable aerosol may comprise: a fluid storage compartment; a heater affixed to a first end; and a mouthpiece affixed to a second end; wherein the heater comprises a first condensation chamber and the mouthpiece comprises a second condensation chamber.

The heater may comprise more than one first condensation chamber and the mouthpiece comprises more than one second condensation chamber. The first condensation chamber and the second condensation chamber may be in fluid communication. The mouthpiece may comprise an aerosol outlet in fluid communication with the second condensation chamber. The mouthpiece may comprise two to more aerosol outlets. The cartridge may meet ISO recycling standards. The cartridge may meet ISO recycling standards for plastic waste.

A device for generating an inhalable aerosol may comprise: a device body comprising a cartridge receptacle; and a detachable cartridge; wherein the cartridge receptacle and the detachable cartridge form a separable coupling, wherein the separable coupling comprises a friction assembly, a snap-fit assembly or a magnetic assembly.

A method of fabricating a device for generating an inhalable aerosol may comprise: providing a device body comprising a cartridge receptacle; and providing a detachable cartridge; wherein the cartridge receptacle and the detachable cartridge form a separable coupling comprising a friction assembly, a snap-fit assembly or a magnetic assembly.

A method of fabricating a cartridge for a device for generating an inhalable aerosol may comprise: providing a fluid storage compartment; affixing a heater to a first end

with a snap-fit coupling; and affixing a mouthpiece to a second end with a snap-fit coupling.

A cartridge for a device for generating an inhalable aerosol with an airflow path may include: a channel comprising a portion of an air inlet passage; a second air passage in fluid communication with the channel; a heater chamber in fluid communication with the second air passage; a first condensation chamber in fluid communication with the heater chamber; a second condensation chamber in fluid communication with the first condensation chamber; and an aerosol outlet in fluid communication with second condensation chamber.

A cartridge for a device for generating an inhalable aerosol may comprise: a fluid storage compartment; a heater affixed to a first end; and a mouthpiece affixed to a second end; wherein said mouthpiece comprises two or more aerosol outlets.

A system for providing power to an electronic device for generating an inhalable vapor may comprise; a rechargeable power storage device housed within the electronic device for generating an inhalable vapor; two or more pins that are accessible from an exterior surface of the electronic device for generating an inhalable vapor, wherein the charging pins are in electrical communication with the rechargeable power storage device; a charging cradle comprising two or more charging contacts configured to provided power to the rechargeable storage device, wherein the device charging pins are reversible such that the device is charged in the charging cradle for charging with a first charging pin on the device in contact a first charging contact on the charging cradle and a second charging pin on the device in contact with second charging contact on the charging cradle and with the first charging pin on the device in contact with second charging contact on the charging cradle and the second charging pin on the device in contact with the first charging contact on the charging cradle.

The charging pins may be visible on an exterior housing of the device. The user may permanently disable the device by opening the housing. The user may permanently destroy the device by opening the housing.

Additional aspects and advantages of the present disclosure will become readily apparent to those skilled in this art from the following detailed description, wherein only illustrative embodiments of the present disclosure are shown and described. As will be realized, the present disclosure is capable of other and different embodiments, and its several details are capable of modifications in various obvious respects, all without departing from the disclosure. Accordingly, the drawings and description are to be regarded as illustrative in nature, and not as restrictive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is an illustrative cross-sectional view of an exemplary vaporization device.

FIG. **2** is an illustrative cross-sectional view of an exemplary vaporization device with various electronic features and valves.

FIG. **3** is an illustrative sectional view of another exemplary vaporization device comprising a condensation chamber, air inlet and aeration vent in the mouthpiece.

FIGS. **4**A-**4**C is an illustrative example of an oven section of another exemplary vaporization device configuration with an access lid, comprising an oven having an air inlet, air outlet, and an additional aeration vent in the airflow pathway, after the oven.

FIG. **5** is an illustrative isometric view of an assembled inhalable aerosol device.

FIGS. **6**A-**6**D are illustrative arrangements and section views of the device body and sub-components.

FIG. **7**A is an illustrative isometric view of an assembled cartridge.

FIG. **7**B is an illustrative exploded isometric view of a cartridge assembly

FIG. **7**C is a side section view of FIG. **3**A illustrating the inlet channel, inlet hole and relative placement of the wick, resistive heating element, and heater contacts, and the heater chamber inside of the heater.

FIG. **8**A is an illustrative end section view of an exemplary cartridge inside the heater.

FIG. **8**B is an illustrative side view of the cartridge with the cap removed and heater shown in shadow/outline.

FIGS. **9**A-**9**L are an illustrative sequence of the assembly method for the cartridge.

FIGS. **10**A-**10**C are illustrative sequences showing the airflow/vapor path for the cartridge.

FIGS. **11-13** represent an illustrative assembly sequence for assembling the main components of the device.

FIG. **14** illustrates front, side and section views of the assembled inhalable aerosol device.

FIG. **15** is an illustrative view of an activated, assembled inhalable aerosol device.

FIGS. **16**A-**16**C are representative illustrations of a charging device for the aerosol device and the application of the charger with the device.

FIGS. **17**A and **17**B are representative illustrations of a proportional-integral-derivative controller (PID) block diagram and circuit diagram representing the essential components in a device to control coil temperature.

FIG. **18** is a device with charging contacts visible from an exterior housing of the device.

FIG. **19** is an exploded view of a charging assembly of a device.

FIG. **20** is a detailed view of a charging assembly of a device.

FIG. **21** is a detailed view of charging pins in a charging assembly of a device.

FIG. **22** is a device in a charging cradle.

FIG. **23** is a circuit provided on a PCB configured to permit a device to comprise reversible charging contacts.

FIGS. **24**A and **24**B show top and bottom perspective views, respectively of a cartridge device holding a vaporizable material for securely coupling with an electronic inhalable aerosol device as described herein.

FIGS. **25**A and **25**B show front a side views, respectively, of the cartridge of FIGS. **24**A-**24**B.

FIG. **26**A shows a section through a cartridge device holding a vaporizable material for securely coupling with an electronic inhalable aerosol device and indicates exemplary dimensions (in mm).

FIG. **26**B shows a side view of the cartridge of FIG. **26**A, indicating where the sectional view of FIG. **26**A was taken.

FIGS. **27**A and **27**B show an exemplary vaporizer device without a cartridge attached. FIG. **27**A is a side view and FIG. **27**B shows a sectional view with exemplary dimensions of the rectangular opening for holding and making electrical contact with a cartridge.

FIG. **28**A shows a perspective view of a vaporizer coupled to a cartridge as described herein.

FIG. **28**B shows a side view of the vaporizer of FIG. **28**A.

FIG. **28**C shows a sectional view through the vaporizer of FIG. **28**B taken through the dashed line.

FIG. **28**D is an enlarged view of the region showing the electrical and mechanical connection between the cartridge and the vaporizer indicted by the circular region D.

FIGS. **29**A-**29**H illustrate side profiles of alternative variations of cartridges as described herein.

FIG. **30** is an exploded view of one example of a cartridge, including a reservoir, for an electronic cigarette.

FIGS. **31**A-**31**L show cartridges for use with a vaporizer device that each include an opaque mouthpiece that is secured over the proximal end of the transparent storage compartment, and one or more notches in the front side of the mouthpiece that exposes a region of the storage compartment beneath the mouthpiece. In FIGS. **31**A-**31**L the central cannula passing through the storage compartment is visible through the notch and the region below the opaque mouthpiece.

FIG. **32** and FIGS. **33**A-**33**E illustrate exemplary vaporizer apparatuses including a cartridge and a vaporizer; the cartridge is mated in a cartridge receptacle at the proximal end of a vaporizer. The cartridge has an opaque mouthpiece over a storage compartment holding a vaporizable material; the inside of the storage compartment is visible through the storage compartment and a notch in the mouthpiece that mates with a notch through the cartridge receptacle at the proximal end of the vaporizer. FIG. **32** is a perspective front view of the apparatus. FIG. **33**A is a top view of the proximal end, showing the mouthpiece. FIG. **33**B is a bottom view of the distal end. FIGS. **33**C-**33**E are front, side and back views, respectively, of the apparatus.

FIGS. **34**A-**34**L illustrate examples of vaporizer devices similar to that shown in FIG. **33**A-**33**E, in which the notched regions of the cartridge and the vaporizer are different, but provide a window into the inside of the storage compartment, showing the central cannula and the level of any fluid vaporizable material therein.

DETAILED DESCRIPTION

Provided herein are systems and methods for generating a vapor from a material. The vapor may be delivered for inhalation by a user. The material may be a solid, liquid, powder, solution, paste, gel, or any a material with any other physical consistency. The vapor may be delivered to the user for inhalation by a vaporization device. The vaporization device may be a handheld vaporization device. The vaporization device may be held in one hand by the user.

The vaporization device may comprise one or more heating elements the heating element may be a resistive heating element. The heating element may heat the material such that the temperature of the material increases. Vapor may be generated as a result of heating the material. Energy may be required to operate the heating element, the energy may be derived from a battery in electrical communication with the heating element. Alternatively a chemical reaction (e.g., combustion or other exothermic reaction) may provide energy to the heating element.

One or more aspects of the vaporization device may be designed and/or controlled in order to deliver a vapor with one or more specified properties to the user. For example, aspects of the vaporization device that may be designed and/or controlled to deliver the vapor with specified properties may comprise the heating temperature, heating mechanism, device air inlets, internal volume of the device, and/or composition of the material.

In some cases, a vaporization device may have an "atomizer" or "cartomizer" configured to heat an aerosol forming solution (e.g., vaporizable material). The aerosol forming solution may comprise glycerin and/or propylene glycol. The vaporizable material may be heated to a sufficient temperature such that it may vaporize.

An atomizer may be a device or system configured to generate an aerosol. The atomizer may comprise a small heating element configured to heat and/or vaporize at least a portion of the vaporizable material and a wicking material that may draw a liquid vaporizable material in to the atomizer. The wicking material may comprise silica fibers, cotton, ceramic, hemp, stainless steel mesh, and/or rope cables. The wicking material may be configured to draw the liquid vaporizable material in to the atomizer without a pump or other mechanical moving part. A resistance wire may be wrapped around the wicking material and then connected to a positive and negative pole of a current source (e.g., energy source). The resistance wire may be a coil. When the resistance wire is activated the resistance wire (or coil) may have a temperature increase as a result of the current flowing through the resistive wire to generate heat. The heat may be transferred to at least a portion of the vaporizable material through conductive, convective, and/or radiative heat transfer such that at least a portion of the vaporizable material vaporizes.

Alternatively or in addition to the atomizer, the vaporization device may comprise a "cartomizer" to generate an aerosol from the vaporizable material for inhalation by the user. The cartomizer may comprise a cartridge and an atomizer. The cartomizer may comprise a heating element surrounded by a liquid-soaked poly-foam that acts as holder for the vaporiable material (e.g., the liquid). The cartomizer may be reusable, rebuildable, refillable, and/or disposable. The cartomizer may be used with a tank for extra storage of a vaporizable material.

Air may be drawn into the vaporization device to carry the vaporized aerosol away from the heating element, where it then cools and condenses to form liquid particles suspended in air, which may then be drawn out of the mouthpiece by the user.

The vaporization of at least a portion of the vaporizable material may occur at lower temperatures in the vaporization device compared to temperatures required to generate an inhalable vapor in a cigarette. A cigarette may be a device in which a smokable material is burned to generate an inhalable vapor. The lower temperature of the vaporization device may result in less decomposition and/or reaction of the vaporized material, and therefore produce an aerosol with many fewer chemical components compared to a cigarette. In some cases, the vaporization device may generate an aerosol with fewer chemical components that may be harmful to human health compared to a cigarette. Additionally, the vaporization device aerosol particles may undergo nearly complete evaporation in the heating process, the nearly complete evaporation may yield an average particle size (e.g., diameter) value that may be smaller than the average particle size in tobacco or botanical based effluent.

A vaporization device may be a device configured to extract for inhalation one or more active ingredients of plant material, tobacco, and/or a botanical, or other herbs or blends. A vaporization device may be used with pure chemicals and/or humectants that may or may not be mixed with plant material. Vaporization may be alternative to burning (smoking) that may avoid the inhalation of many irritating and/or toxic carcinogenic by-products which may result from the pyrolytic process of burning tobacco or botanical products above 300° C. The vaporization device may operate at a temperature at or below 300° C.

A vaporizer (e.g., vaporization device) may not have an atomizer or cartomizer. Instead the device may comprise an oven. The oven may be at least partially closed. The oven may have a closable opening. The oven may be wrapped with a heating element, alternatively the heating element may be in thermal communication with the oven through another mechanism. A vaporizable material may be placed directly in the oven or in a cartridge fitted in the oven. The heating element in thermal communication with the oven may heat a vaporizable material mass in order to create a gas phase vapor. The heating element may heat the vaporizable material through conductive, convective, and/or radiative heat transfer. The vapor may be released to a vaporization chamber where the gas phase vapor may condense, forming an aerosol cloud having typical liquid vapor particles with particles having a diameter of average mass of approximately 1 micron or greater. In some cases the diameter of average mass may be approximately 0.1-1 micron.

A used herein, the term "vapor" may generally refer to a substance in the gas phase at a temperature lower than its critical point. The vapor may be condensed to a liquid or to a solid by increasing its pressure without reducing the temperature.

As used herein, the term "aerosol" may generally refer to a colloid of fine solid particles or liquid droplets in air or another gas. Examples of aerosols may include clouds, haze, and smoke, including the smoke from tobacco or botanical products. The liquid or solid particles in an aerosol may have varying diameters of average mass that may range from monodisperse aerosols, producible in the laboratory, and containing particles of uniform size; to polydisperse colloidal systems, exhibiting a range of particle sizes. As the sizes of these particles become larger, they have a greater settling speed which causes them to settle out of the aerosol faster, making the appearance of the aerosol less dense and to shorten the time in which the aerosol will linger in air. Interestingly, an aerosol with smaller particles will appear thicker or denser because it has more particles. Particle number has a much bigger impact on light scattering than particle size (at least for the considered ranges of particle size), thus allowing for a vapor cloud with many more smaller particles to appear denser than a cloud having fewer, but larger particle sizes.

As used herein the term "humectant" may generally refer to as a substance that is used to keep things moist. A humectant may attract and retain moisture in the air by absorption, allowing the water to be used by other substances. Humectants are also commonly used in many tobaccos or botanicals and electronic vaporization products to keep products moist and as vapor-forming medium. Examples include propylene glycol, sugar polyols such as glycerol, glycerin, and honey.

Rapid Aeration

In some cases, the vaporization device may be configured to deliver an aerosol with a high particle density. The particle density of the aerosol may refer to the number of the aerosol droplets relative to the volume of air (or other dry gas) between the aerosol droplets. A dense aerosol may easily be visible to a user. In some cases the user may inhale the aerosol and at least a fraction of the aerosol particles may impinge on the lungs and/or mouth of the user. The user may exhale residual aerosol after inhaling the aerosol. When the aerosol is dense the residual aerosol may have sufficient particle density such that the exhaled aerosol is visible to the user. In some cases, a user may prefer the visual effect and/or mouth feel of a dense aerosol.

A vaporization device may comprise a vaporizable material. The vaporizable material may be contained in a cartridge or the vaporizable material may be loosely placed in one or more cavities the vaporization device. A heating element may be provided in the device to elevate the temperature of the vaporizable material such that at least a portion of the vaporizable material forms a vapor. The heating element may heat the vaporizable material by convective heat transfer, conductive heat transfer, and/or radiative heat transfer. The heating element may heat the cartridge and/or the cavity in which the vaporizable material is stored.

Vapor formed upon heating the vaporizable material may be delivered to the user. The vapor may be transported through the device from a first position in the device to a second position in the device. In some cases, the first position may be a location where at least a portion of the vapor was generated, for example, the cartridge or cavity or an area adjacent to the cartridge or cavity. The second position may be a mouthpiece. The user may suck on the mouthpiece to inhale the vapor.

At least a fraction of the vapor may condense after the vapor is generated and before the vapor is inhaled by the user. The vapor may condense in a condensation chamber. The condensation chamber may be a portion of the device that the vapor passes through before delivery to the user. In some cases, the device may include at least one aeration vent, placed in the condensation chamber of the vaporization device. The aeration vent may be configured to introduce ambient air (or other gas) into the vaporization chamber. The air introduced into the vaporization chamber may have a temperature lower than the temperature of a gas and/or gas/vapor mixture in the condensation chamber. Introduction of the relatively lower temperature gas into the vaporization chamber may provide rapid cooling of the heated gas vapor mixture that was generated by heating the vaporizable material. Rapid cooling of the gas vapor mixture may generate a dense aerosol comprising a high concentration of liquid droplets having a smaller diameter and/or smaller average mass compared to an aerosol that is not rapidly cooled prior to inhalation by the user.

An aerosol with a high concentration of liquid droplets having a smaller diameter and/or smaller average mass compared to an aerosol that is not rapidly cooled prior to inhalation by the user may be formed in a two-step process. The first step may occur in the oven chamber where the vaporizable material (e.g., tobacco and/or botanical and humectant blend) may be heated to an elevated temperature. At the elevated temperature, evaporation may happen faster than at room temperature and the oven chamber may fill with the vapor phase of the humectants. The humectant may continue to evaporate until the partial pressure of the humectant is equal to the saturation pressure. At this point, the gas is said to have a saturation ratio of 1 (S=Ppartial/P sat).

In the second step, the gas (e.g., vapor and air) may exit the oven and enter a condenser or condensation chamber and begin to cool. As the gas phase vapor cools, the saturation pressure may decrease. As the saturation pressure decreases, the saturation ratio may increase and the vapor may begin to condense, forming droplets. In some devices, with the absence of added cooling aeration, the cooling may be relatively slower such that high saturation pressures may not be reached, and the droplets that form in the devices without added cooling aeration may be relatively larger and fewer in numbers. When cooler air is introduced, a temperature gradient may be formed between the cooler air and the relatively warmer gas in the device. Mixing between the

cooler air and the relatively warmer gas in a confined space inside of the vaporization device may lead to rapid cooling. The rapid cooling may generate high saturation ratios, small particles, and high concentrations of smaller particles, forming a thicker, denser vapor cloud compared to particles generated in a device without the aeration vents.

For the purpose of this disclosure, when referring to ratios of humectants such as vegetable glycerol or propylene glycol, "about" means a variation of 5%, 10%, 20% or 25% depending on the embodiment.

For the purpose of this disclosure, when referring to a diameter of average mass in particle sizes, "about" means a variation of 5%, 10%, 20% or 25% depending on the embodiment.

A vaporization device configured to rapidly cool a vapor may comprise: a mouthpiece comprising an aerosol outlet at a first end of the device; an oven comprising an oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein; a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol; an air inlet that originates a first airflow path that includes the oven chamber and then the condensation chamber, an aeration vent that originates a second airflow path that joins the first airflow path prior to or within the condensation chamber after the vapor is formed in the oven chamber, wherein the joined first airflow path and second airflow path are configured to deliver the inhalable aerosol formed in the condensation chamber through the aerosol outlet of the mouthpiece to a user.

In some embodiments, the oven is within a body of the device. The oven chamber may comprise an oven chamber inlet and an oven chamber outlet. The oven may further comprise a first valve at the oven chamber inlet, and a second valve at the oven chamber outlet.

The oven may be contained within a device housing. In some cases the body of the device may comprise the aeration vent and/or the condenser. The body of the device may comprise one or more air inlets. The body of the device may comprise a housing that holds and/or at least partially contains one or more elements of the device.

The mouthpiece may be connected to the body. The mouthpiece may be connected to the oven. The mouthpiece may be connected to a housing that at least partially encloses the oven. In some cases, the mouthpiece may be separable from the oven, the body, and/or the housing that at least partially encloses the oven. The mouthpiece may comprise at least one of the air inlet, the aeration vent, and the condenser. The mouthpiece may be integral to the body of the device. The body of the device may comprise the oven.

In some cases, the one or more aeration vents may comprise a valve. The valve may regulate a flow rate of air entering the device through the aeration vent. The valve may be controlled through a mechanical and/or electrical control system.

A vaporization device configured to rapidly cool a vapor may comprise: a body, a mouthpiece, an aerosol outlet, a condenser with a condensation chamber, a heater, an oven with an oven chamber, a primary airflow inlet, and at least one aeration vent provided in the body, downstream of the oven, and upstream of the mouthpiece.

FIG. **1** shows an example of a vaporization device configured to rapidly cool a vapor. The device **100**, may comprise a body **101**. The body may house and/or integrate with one or more components of the device. The body may house and/or integrate with a mouthpiece **102**. The mouthpiece **102** may have an aerosol outlet **122**. A user may inhale the generated aerosol through the aerosol outlet **122** on the mouthpiece **102**. The body may house and/or integrate with an oven region **104**. The oven region **104** may comprise an oven chamber where vapor forming medium **106** may be placed. The vapor forming medium may include tobacco and/or botanicals, with or without a secondary humectant. In some cases the vapor forming medium may be contained in a removable and/or refillable cartridge.

Air may be drawn into the device through a primary air inlet **121**. The primary air inlet **121** may be on an end of the device **100** opposite the mouthpiece **102**. Alternatively, the primary air inlet **121** may be adjacent to the mouthpiece **102**. In some cases, a pressure drop sufficient to pull air into the device through the primary air inlet **121** may be due to a user puffing on the mouthpiece **102**.

The vapor forming medium (e.g., vaporizable material) may be heated in the oven chamber by a heater **105**, to generate elevated temperature gas phases (vapor) of the tobacco or botanical and humectant/vapor forming components. The heater **105** may transfer heat to the vapor forming medium through conductive, convective, and/or radiative heat transfer. The generated vapor may be drawn out of the oven region and into the condensation chamber **103***a*, of the condenser **103** where the vapors may begin to cool and condense into micro-particles or droplets suspended in air, thus creating the initial formation of an aerosol, before being drawn out of the mouthpiece through the aerosol outlet **122**.

In some cases, relatively cooler air may be introduced into the condensation chamber **103***a*, through an aeration vent **107** such that the vapor condenses more rapidly compared to a vapor in a device without the aeration vent **107**. Rapidly cooling the vapor may create a denser aerosol cloud having particles with a diameter of average mass of less than or equal to about 1 micron, and depending on the mixture ratio of the vapor-forming humectant, particles with a diameter of average mass of less than or equal to about 0.5 micron

Also described herein are devices for generating an inhalable aerosol said device comprising a body with a mouthpiece at one end, an attached body at the other end comprising a condensation chamber, a heater, an oven, wherein the oven comprises a first valve in the airflow path at the primary airflow inlet of the oven chamber, and a second valve at the outlet end of the oven chamber, and at least one aeration vent provided in the body, downstream of the oven, and upstream of the mouthpiece.

FIG. **2** shows a diagram of an alternative embodiment of the vaporization device **200**. The vaporization device may have a body **201**. The body **201** may integrate with and/or contain one or more components of the device. The body may integrate with or be connected to a mouthpiece **202**

The body may comprise an oven region **204**, with an oven chamber **204***a* having a first constricting valve **208** in the primary air inlet of the oven chamber and a second constricting valve **209** at the oven chamber outlet. The oven chamber **204***a* may be sealed with a tobacco or botanical and/or humectant/vapor forming medium **206** therein. The seal may be an air tight and/or liquid tight seal. The heater may be provided to the oven chamber with a heater **205**. The heater **205** may be in thermal communication with the oven, for example the heater may be surrounding the oven chamber during the vaporization process. Heater may contact the oven. The heater may be wrapped around the oven. Before inhalation and before air is drawn in through a primary air inlet **221**, pressure may build in the sealed oven chamber as heat is continually added. The pressure may build due to a phase change of the vaporizable material. Elevated temperature gas phases (vapor) of the tobacco or botanical and humectant/vapor forming components may be achieved by

continually adding heat to the oven. This heated pressurization process may generate even higher saturation ratios when the valves **208**, **209** are opened during inhalation. The higher saturation ratios may cause relatively higher particle concentrations of gas phase humectant in the resultant aerosol. When the vapor is drawn out of the oven region and into the condensation chamber **203***a* of the condenser **203**, for example by inhalation by the user, the gas phase humectant vapors may be exposed to additional air through an aeration vent **207**, and the vapors may begin to cool and condense into droplets suspended in air. As described previously the aerosol may be drawn through the mouthpiece **222** by the user. This condensation process may be further refined by adding an additional valve **210**, to the aeration vent **207** to further control the air-vapor mixture process.

FIG. **2** also illustrates an exemplary embodiment of the additional components which would be found in a vaporizing device, including a power source or battery **211**, a printed circuit board **212**, a temperature regulator **213**, and operational switches (not shown), housed within an internal electronics housing **214**, to isolate them from the damaging effects of the moisture in the vapor and/or aerosol. The additional components may be found in a vaporizing device that may or may not comprise an aeration vent as described above.

In some embodiments of the vaporization device, components of the device are user serviceable, such as the power source or battery. These components may be replaceable or rechargeable.

Also described herein are devices for generating an inhalable aerosol said device comprising a first body, a mouthpiece having an aerosol outlet, a condensation chamber within a condenser and an airflow inlet and channel, an attached second body, comprising a heater and oven with an oven chamber, wherein said airflow channel is upstream of the oven and the mouthpiece outlet to provide airflow through the device, across the oven, and into the condensation chamber where an auxiliary aeration vent is provided.

FIG. **3** shows a section view of a vaporization device **300**. The device **300** may comprise a body **301**. The body may be connected to or integral with a mouthpiece **302** at one end. The mouthpiece may comprise a condensation chamber **303***a* within a condenser section **303** and an airflow inlet **321** and air channel **323**. The device body may comprise a proximally located oven **304** comprising an oven chamber **304***a*. The oven chamber may be in the body of the device. A vapor forming medium **306** (e.g., vaporizable material) comprising tobacco or botanical and humectant vapor forming medium may be placed in the oven. The vapor forming medium may be in direct contact with an air channel **323** from the mouthpiece. The tobacco or botanical may be heated by heater **305** surrounding the oven chamber, to generate elevated temperature gas phases (vapor) of the tobacco or botanical and humectant/vapor forming components and air drawn in through a primary air inlet **321**, across the oven, and into the condensation chamber **303***a* of the condenser region **303** due to a user puffing on the mouthpiece. Once in the condensation chamber where the gas phase humectant vapors begin to cool and condense into droplets suspended in air, additional air is allowed to enter through aeration vent **307**, thus, once again creating a denser aerosol cloud having particles with a diameter of average mass of less than a typical vaporization device without an added aeration vent, before being drawn out of the mouthpiece through the aerosol outlet **322**.

The device may comprises a mouthpiece comprising an aerosol outlet at a first end of the device and an air inlet that originates a first airflow path; an oven comprising an oven chamber that is in the first airflow path and includes the oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein, a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol, an aeration vent that originates a second airflow path that allows air from the aeration vent to join the first airflow path prior to or within the condensation chamber and downstream from the oven chamber thereby forming a joined path, wherein the joined path is configured to deliver the inhalable aerosol formed in the condensation chamber through the aerosol outlet of the mouthpiece to a user.

The device may comprise a mouthpiece comprising an aerosol outlet at a first end of the device, an air inlet that originates a first airflow path, and an aeration vent that originates a second airflow path that allows air from the aeration vent to join the first airflow path; an oven comprising an oven chamber that is in the first airflow path and includes the oven chamber and a heater for heating a vapor forming medium in the oven chamber and for forming a vapor therein, a condenser comprising a condensation chamber in which the vapor forms the inhalable aerosol and wherein air from the aeration vent joins the first airflow path prior to or within the condensation chamber and downstream from the oven chamber thereby forming a joined path, wherein the joined path is configured to deliver the inhalable aerosol through the aerosol outlet of the mouthpiece to a user, as illustrated in exemplary FIG. **3**.

The device may comprise a body with one or more separable components. For example, the mouthpiece may be separably attached to the body comprising the condensation chamber, a heater, and an oven, as illustrated in exemplary FIG. **1** or **2**.

The device may comprise a body with one or more separable components. For example, the mouthpiece may be separably attached to the body. The mouthpiece may comprise the condensation chamber, and may be attached to or immediately adjacent to the oven and which is separable from the body comprising a heater, and the oven, as illustrated in exemplary FIG. **3**.

The at least one aeration vent may be located in the condensation chamber of the condenser, as illustrated in exemplary FIG. **1**, **2**, or **3**. The at least one aeration vent may comprise a third valve in the airflow path of the at least one aeration vent, as illustrated in exemplary FIG. **2**. The first, second and third valve is a check valve, a clack valve, a non-return valve, or a one-way valve. In any of the preceding variations, the first, second or third valve may be mechanically actuated, electronically actuated or manually actuated. One skilled in the art will recognize after reading this disclosure that this device may be modified in a way such that any one, or each of these openings or vents could be configured to have a different combination or variation of mechanisms as described to control airflow, pressure and temperature of the vapor created and aerosol being generated by these device configurations, including a manually operated opening or vent with or without a valve.

The device may further comprise at least one of: a power source, a printed circuit board, a switch, and a temperature regulator. Alternately, one skilled in the art would recognize that each configuration previously described will also accommodate said power source (battery), switch, printed circuit board, or temperature regulator as appropriate, in the body.

The device may be disposable when the supply of prepackaged aerosol-forming media is exhausted. Alternatively,

the device may be rechargeable such that the battery may be rechargeable or replaceable, and/or the aerosol-forming media may be refilled, by the user/operator of the device. Still further, the device may be rechargeable such that the battery may be rechargeable or replaceable, and/or the operator may also add or refill a tobacco or botanical component, in addition to a refillable or replaceable aerosol-forming media to the device.

As illustrated in FIG. **1**, **2** or **3**, the vaporization device may comprise tobacco or a botanical heated in said oven chamber, wherein said tobacco or botanical further comprises humectants to produce an aerosol comprising gas phase components of the humectant and tobacco or botanical. The gas phase humectant and tobacco or botanical vapor produced by said heated aerosol forming media **106**, **206**, **306** may further be mixed with air from a special aeration vent **107**, **207**, **307** after exiting the oven area **104**, **204**, **304** and entering a condensation chamber **103***a*, **203***a*, **303***a* to cool and condense said gas phase vapors to produce a far denser, thicker aerosol comprising more particles than would have otherwise been produced without the extra cooling air, with a diameter of average mass of less than or equal to about 1 micron.

Each aerosol configuration produced by mixing the gas phase vapors with the cool air may comprise a different range of particles, for example; with a diameter of average mass of less than or equal to about 0.9 micron; less than or equal to about 0.8 micron; less than or equal to about 0.7 micron; less than or equal to about 0.6 micron; and even an aerosol comprising particle diameters of average mass of less than or equal to about 0.5 micron.

The possible variations and ranges of aerosol density are great in that the possible number of combinations of temperature, pressure, tobacco or botanical choices and humectant selections are numerous. However, by excluding the tobacco or botanical choices and limiting the temperatures ranges and the humectant ratios to those described herein, the inventor has demonstrated that this device will produce a far denser, thicker aerosol comprising more particles than would have otherwise been produced without the extra cooling air, with a diameter of average mass of less than or equal to about 1 micron.

The humectant may comprise glycerol or vegetable glycerol as a vapor-forming medium.

The humectant may comprise propylene glycol as a vapor-forming medium.

In preferred embodiments, the humectant may comprise a ratio of vegetable glycerol to propylene glycol as a vapor-forming medium. The ranges of said ratio may vary between a ratio of about 100:0 vegetable glycerol to propylene glycol and a ratio of about 50:50 vegetable glycerol to propylene glycol. The difference in preferred ratios within the above stated range may vary by as little as 1, for example, said ratio may be about 99:1 vegetable glycerol to propylene glycol. However, more commonly said ratios would vary in increments of about 5, for example, about 95:5 vegetable glycerol to propylene glycol; or about 85:15 vegetable glycerol to propylene glycol; or about 55:45 vegetable glycerol to propylene glycol.

In a preferred embodiment the ratio for the vapor forming medium will be between the ratios of about 80:20 vegetable glycerol to propylene glycol, and about 60:40 vegetable glycerol to propylene glycol.

In a most preferred embodiment, the ratio for the vapor forming medium will be about 70:30 vegetable glycerol to propylene glycol.

In any of the preferred embodiments, the humectant may further comprise flavoring products. These flavorings may include enhancers comprising cocoa solids, licorice, tobacco or botanical extracts, and various sugars, to name but a few.

The tobacco or botanical may be heated in the oven up to its pyrolytic temperature, which as noted previously is most commonly measured in the range of 300-1000° C.

In preferred embodiments, the tobacco or botanical is heated to about 300° C. at most. In other preferred embodiments, the tobacco or botanical is heated to about 200° C. at most. In still other preferred embodiments, the tobacco or botanical is heated to about 160° C. at most. It should be noted that in these lower temperature ranges (<300° C.), pyrolysis of tobacco or botanical does not typically occur, yet vapor formation of the tobacco or botanical components and flavoring products does occur. In addition, vapor formation of the components of the humectant, mixed at various ratios will also occur, resulting in nearly complete vaporization, depending on the temperature, since propylene glycol has a boiling point of about 180°-190° C. and vegetable glycerin will boil at approximately 280°-290° C.

In still other preferred embodiments, the aerosol produced by said heated tobacco or botanical and humectant is mixed with air provided through an aeration vent.

In still other preferred embodiments, the aerosol produced by said heated tobacco or botanical and humectant mixed with air, is cooled to a temperature of about 50°-70° C. at most, and even as low as 35° C. before exiting the mouthpiece, depending on the air temperature being mixed into the condensation chamber. In some embodiments, the temperature is cooled to about 35°-55° C. at most, and may have a fluctuating range of ±about 10° C. or more within the overall range of about 35°-70° C.

Also described herein are vaporization devices for generating an inhalable aerosol comprising a unique oven configuration, wherein said oven comprises an access lid and an auxiliary aeration vent located within the airflow channel immediately downstream of the oven and before the aeration chamber. In this configuration, the user may directly access the oven by removing the access lid, providing the user with the ability to recharge the device with vaporization material.

In addition, having the added aeration vent in the airflow channel immediately after the oven and ahead of the vaporization chamber provides the user with added control over the amount of air entering the aeration chamber downstream and the cooling rate of the aerosol before it enters the aeration chamber.

As noted in FIGS. **4**A-**4**C, the device **400** may comprise a body **401**, having an air inlet **421** allowing initial air for the heating process into the oven region **404**. After heating the tobacco or botanical, and humectant (heater not shown), the gas phase humectant vapor generated may travel down the airflow channel **423**, passing the added aeration vent **407** wherein the user may selectively increase airflow into the heated vapor. The user may selectively increase and/or decrease the airflow to the heated vapor by controlling a valve in communication with the aeration vent **407**. In some cases, the device may not have an aeration vent. Airflow into the heated vapor through the aeration vent may decrease the vapor temperature before exiting the airflow channel at the outlet **422**, and increase the condensation rate and vapor density by decreasing the diameter of the vapor particles within the aeration chamber (not shown), thus producing a thicker, denser vapor compared to the vapor generated by a device without the aeration vent. The user may also access the oven chamber **404***a* to recharge or reload the device **400**,

through an access lid **430** provided therein, making the device user serviceable. The access lid may be provided on a device with or without an aeration vent.

Provided herein is a method for generating an inhalable aerosol, the method comprising: providing an vaporization device, wherein said device produces a vapor comprising particle diameters of average mass of about 1 micron or less, wherein the vapor is formed by heating a vapor forming medium in an oven chamber of the device to a first temperature below the pyrolytic temperature of the vapor forming medium, and cooling the vapor in a condensation chamber to a temperature below the first temperature, before exiting an aerosol outlet of said device.

In some embodiments the vapor may be cooled by mixing relatively cooler air with the vapor in the condensation chamber during the condensation phase, after leaving the oven, where condensation of the gas phase humectants occurs more rapidly due to high saturation ratios being achieved at the moment of aeration, producing a higher concentration of smaller particles, with fewer by-products, in a denser aerosol, than would normally occur in a standard vaporization or aerosol generating device.

In some embodiments, formation of an inhalable aerosol is a two-step process. The first step occurs in the oven where the tobacco or botanical and humectant blend is heated to an elevated temperature. At the elevated temperature, evaporation happens faster than at room temperature and the oven chamber fills with the vapor phase of the humectants. The humectant will continue to evaporate until the partial pressure of the humectant is equal to the saturation pressure. At this point, the gas is said to have a saturation ratio of 1 (S=Ppartial/Psat).

In the second step, the gas leaves the oven chamber, passes to a condensation chamber in a condenser and begins to cool. As the gas phase vapor cools, the saturation pressure also goes down, causing the saturation ratio to rise, and the vapor to condensate, forming droplets. When cooling air is introduced, the large temperature gradient between the two fluids mixing in a confined space leads to very rapid cooling, causing high saturation ratios, small particles, and higher concentrations of smaller particles, forming a thicker, denser vapor cloud.

Provided herein is a method for generating an inhalable aerosol comprising: a vaporization device having a body with a mouthpiece at one end, and an attached body at the other end comprising; a condenser with a condensation chamber, a heater, an oven with an oven chamber, and at least one aeration vent provided in the body, downstream of the oven, and upstream of the mouthpiece, wherein tobacco or botanical comprising a humectant is heated in said oven chamber to produce a vapor comprising gas phase humectants.

As previously described, a vaporization device having an auxiliary aeration vent located in the condensation chamber capable of supplying cool air (relative to the heated gas components) to the gas phase vapors and tobacco or botanical components exiting the oven region, may be utilized to provide a method for generating a far denser, thicker aerosol comprising more particles than would have otherwise been produced without the extra cooling air, with a diameter of average mass of less than or equal to about 1 micron.

In another aspect, provided herein is a method for generating an inhalable aerosol comprising: a vaporization device, having a body with a mouthpiece at one end, and an attached body at the other end comprising: a condenser with a condensation chamber, a heater, an oven with an oven chamber, wherein said oven chamber further comprises a first valve in the airflow path at the inlet end of the oven chamber, and a second valve at the outlet end of the oven chamber; and at least one aeration vent provided in said body, downstream of the oven, and upstream of the mouthpiece wherein tobacco or botanical comprising a humectant is heated in said oven chamber to produce a vapor comprising gas phase humectants.

As illustrated in exemplary FIG. **2**, by sealing the oven chamber **204***a* with a tobacco or botanical and humectant vapor forming medium **206** therein, and applying heat with the heater **205** during the vaporization process, before inhalation and air is drawn in through a primary air inlet **221**, the pressure will build in the oven chamber as heat is continually added with an electronic heating circuit generated through the combination of the battery **211**, printed circuit board **212**, temperature regulator **213**, and operator controlled switches (not shown), to generate even greater elevated temperature gas phase humectants (vapor) of the tobacco or botanical and humectant vapor forming components. This heated pressurization process generates even higher saturation ratios when the valves **208**, **209** are opened during inhalation, which cause higher particle concentrations in the resultant aerosol, when the vapor is drawn out of the oven region and into the condensation chamber **203***a*, where they are again exposed to additional air through an aeration vent **207**, and the vapors begin to cool and condense into droplets suspended in air, as described previously before the aerosol is withdrawn through the mouthpiece **222**. The inventor also notes that this condensation process may be further refined by adding an additional valve **210**, to the aeration vent **207** to further control the air-vapor mixture process.

In some embodiments of any one of the inventive methods, the first, second and/or third valve is a one-way valve, a check valve, a clack valve, or a non-return valve. The first, second and/or third valve may be mechanically actuated. The first, second and/or third valve may be electronically actuated. The first, second and/or third valve may be automatically actuated. The first, second and/or third valve may be manually actuated either directly by a user or indirectly in response to an input command from a user to a control system that actuates the first, second and/or third valve.

In other aspects of the inventive methods, said device further comprises at least one of: a power source, a printed circuit board, or a temperature regulator.

In any of the preceding aspects of the inventive method, one skilled in the art will recognize after reading this disclosure that this method may be modified in a way such that any one, or each of these openings or vents could be configured to have a different combination or variation of mechanisms or electronics as described to control airflow, pressure and temperature of the vapor created and aerosol being generated by these device configurations, including a manually operated opening or vent with or without a valve.

The possible variations and ranges of aerosol density are great in that the possible number of temperature, pressure, tobacco or botanical choices and humectant selections and combinations are numerous. However, by excluding the tobacco or botanical choices and limiting the temperatures to within the ranges and the humectant ratios described herein, the inventor has demonstrated a method for generating a far denser, thicker aerosol comprising more particles than would have otherwise been produced without the extra cooling air, with a diameter of average mass of less than or equal to 1 micron.

In some embodiments of the inventive methods, the humectant comprises a ratio of vegetable glycerol to propylene glycol as a vapor-forming medium. The ranges of

said ratio will vary between a ratio of about 100:0 vegetable glycerol to propylene glycol and a ratio of about 50:50 vegetable glycerol to propylene glycol. The difference in preferred ratios within the above stated range may vary by as little as 1, for example, said ratio may be about 99:1 vegetable glycerol to propylene glycol. However, more commonly said ratios would vary in increments of 5, for example, about 95:5 vegetable glycerol to propylene glycol; or about 85:15 vegetable glycerol to propylene glycol; or about 55:45 vegetable glycerol to propylene glycol.

Because vegetable glycerol is less volatile than propylene glycol, it will recondense in greater proportions. A humectant with higher concentrations of glycerol will generate a thicker aerosol. The addition of propylene glycol will lead to an aerosol with a reduced concentration of condensed phase particles and an increased concentration of vapor phase effluent. This vapor phase effluent is often perceived as a tickle or harshness in the throat when the aerosol is inhaled. To some consumers, varying degrees of this sensation may be desirable. The ratio of vegetable glycerol to propylene glycol may be manipulated to balance aerosol thickness with the right amount of "throat tickle."

In a preferred embodiment of the method, the ratio for the vapor forming medium will be between the ratios of about 80:20 vegetable glycerol to propylene glycol, and about 60:40 vegetable glycerol to propylene glycol.

In a most preferred embodiment of the method, the ratio for the vapor forming medium will be about 70:30 vegetable glycerol to propylene glycol. On will envision that there will be blends with varying ratios for consumers with varying preferences.

In any of the preferred embodiments of the method, the humectant further comprises flavoring products. These flavorings include enhancers such as cocoa solids, licorice, tobacco or botanical extracts, and various sugars, to name a few.

In some embodiments of the method, the tobacco or botanical is heated to its pyrolytic temperature.

In preferred embodiments of the method, the tobacco or botanical is heated to about 300° C. at most.

In other preferred embodiments of the method, the tobacco or botanical is heated to about 200° C. at most. In still other embodiments of the method, the tobacco or botanical is heated to about 160° C. at most.

As noted previously, at these lower temperatures, (<300° C.), pyrolysis of tobacco or botanical does not typically occur, yet vapor formation of the tobacco or botanical components and flavoring products does occur. As may be inferred from the data supplied by Baker et al., an aerosol produced at these temperatures is also substantially free from Hoffman analytes or at least 70% less Hoffman analytes than a common tobacco or botanical cigarette and scores significantly better on the Ames test than a substance generated by burning a common cigarette. In addition, vapor formation of the components of the humectant, mixed at various ratios will also occur, resulting in nearly complete vaporization, depending on the temperature, since propylene glycol has a boiling point of about 180°-190° C. and vegetable glycerin will boil at approximately 280°-290° C.

In any one of the preceding methods, said inhalable aerosol produced by tobacco or a botanical comprising a humectant and heated in said oven produces an aerosol comprising gas phase humectants is further mixed with air provided through an aeration vent.

In any one of the preceding methods, said aerosol produced by said heated tobacco or botanical and humectant mixed with air, is cooled to a temperature of about 50°-70° C., and even as low as 35° C., before exiting the mouthpiece. In some embodiments, the temperature is cooled to about 35°-55° C. at most, and may have a fluctuating range of ±about 10° C. or more within the overall range of about 35°-70° C.

In some embodiments of the method, the vapor comprising gas phase humectant may be mixed with air to produce an aerosol comprising particle diameters of average mass of less than or equal to about 1 micron.

In other embodiments of the method, each aerosol configuration produced by mixing the gas phase vapors with the cool air may comprise a different range of particles, for example; with a diameter of average mass of less than or equal to about 0.9 micron; less than or equal to about 0.8 micron; less than or equal to about 0.7 micron; less than or equal to about 0.6 micron; and even an aerosol comprising particle diameters of average mass of less than or equal to about 0.5 micron.

Cartridge Design and Vapor Generation from Material in Cartridge

In some cases, a vaporization device may be configured to generate an inhalable aerosol. A device may be a self-contained vaporization device. The device may comprise an elongated body which functions to complement aspects of a separable and recyclable cartridge with air inlet channels, air passages, multiple condensation chambers, flexible heater contacts, and multiple aerosol outlets. Additionally, the cartridge may be configured for ease of manufacture and assembly.

Provided herein is a vaporization device for generating an inhalable aerosol. The device may comprise a device body, a separable cartridge assembly further comprising a heater, at least one condensation chamber, and a mouthpiece. The device provides for compact assembly and disassembly of components with detachable couplings; overheat shut-off protection for the resistive heating element; an air inlet passage (an enclosed channel) formed by the assembly of the device body and a separable cartridge; at least one condensation chamber within the separable cartridge assembly; heater contacts; and one or more refillable, reusable, and/or recyclable components.

Provided herein is a device for generating an inhalable aerosol comprising: a device body comprising a cartridge receptacle; a cartridge comprising: a storage compartment, and a channel integral to an exterior surface of the cartridge, and an air inlet passage formed by the channel and an internal surface of the cartridge receptacle when the cartridge is inserted into the cartridge receptacle. The cartridge may be formed from a metal, plastic, ceramic, and/or composite material. The storage compartment may hold a vaporizable material. FIG. **7**A shows an example of a cartridge **30** for use in the device. The vaporizable material may be a liquid at or near room temperature. In some cases the vaporizable material may be a liquid below room temperature. The channel may form a first side of the air inlet passage, and an internal surface of the cartridge receptacle may form a second side of the air inlet passage, as illustrated in various non-limiting aspects of FIGS. **5**-**6**D, **7**C, **8**A, **8**B, and **10**A

Provided herein is a device for generating an inhalable aerosol. The device may comprise a body that houses, contains, and or integrates with one or more components of the device. The device body may comprise a cartridge receptacle. The cartridge receptacle may comprise a channel integral to an interior surface of the cartridge receptacle; and an air inlet passage formed by the channel and an external surface of the cartridge when the cartridge is inserted into

the cartridge receptacle. A cartridge may be fitted and/or inserted into the cartridge receptacle. The cartridge may have a fluid storage compartment. The channel may form a first side of the air inlet passage, and an external surface of the cartridge forms a second side of the air inlet passage. The channel may comprise at least one of: a groove; a trough; a track; a depression; a dent; a furrow; a trench; a crease; and a gutter. The integral channel may comprise walls that are either recessed into the surface or protrude from the surface where it is formed. The internal side walls of the channel may form additional sides of the air inlet passage. The channel may have a round, oval, square, rectangular, or other shaped cross section. The channel may have a closed cross section. The channel may be about 0.1 cm, 0.5 cm, 1 cm, 2 cm, or 5 cm wide. The channel may be about 0.1 mm, 0.5 mm, 1 mm, 2 mm, or 5 mm deep. The channel may be about 0.1 cm, 0.5 cm, 1 cm, 2 cm, or 5 cm long. There may be at least 1 channel.

In some embodiments, the cartridge may further comprise a second air passage in fluid communication with the air inlet passage to the fluid storage compartment, wherein the second air passage is formed through the material of the cartridge.

FIGS. **5**-**7**C show various views of a compact electronic device assembly **10** for generating an inhalable aerosol. The compact electronic device **10** may comprise a device body **20** with a cartridge receptacle **21** for receiving a cartridge **30**. The device body may have a square or rectangular cross section. Alternatively, the cross section of the body may be any other regular or irregular shape. The cartridge receptacle may be shaped to receive an opened cartridge **30***a* or "pod". The cartridge may be opened when a protective cap is removed from a surface of the cartridge. In some cases, the cartridge may be opened when a hole or opening is formed on a surface of the cartridge. The pod **30***a* may be inserted into an open end of the cartridge receptacle **21** so that an exposed first heater contact tips **33***a* on the heater contacts **33** of the pod make contact with the second heater contacts **22** of the device body, thus forming the device assembly **10**.

Referring to FIG. **14**, it is apparent in the plan view that when the pod **30***a* is inserted into the notched body of the cartridge receptacle **21**, the channel air inlet **50** is left exposed. The size of the channel air inlet **50** may be varied by altering the configuration of the notch in the cartridge receptacle **21**.

The device body may further comprise a rechargeable battery, a printed circuit board (PCB) **24** containing a microcontroller with the operating logic and software instructions for the device, a pressure switch **27** for sensing the user's puffing action to activate the heater circuit, an indicator light **26**, charging contacts (not shown), and an optional charging magnet or magnetic contact (not shown). The cartridge may further comprise a heater **36**. The heater may be powered by the rechargeable battery. The temperature of the heater may be controlled by the microcontroller. The heater may be attached to a first end of the cartridge.

In some embodiments, the heater may comprise a heater chamber **37**, a first pair of heater contacts **33**, **33'**, a fluid wick **34**, and a resistive heating element **35** in contact with the wick. The first pair of heater contacts may comprise thin plates affixed about the sides of the heater chamber. The fluid wick and resistive heating element may be suspended between the heater contacts.

In some embodiments, there may be two or more resistive heating elements **35**, **35'** and two or more wicks **34**, **34'**. In some of the embodiments, the heater contact **33** may comprise: a flat plate; a male contact; a female receptacle, or both; a flexible contact and/or copper alloy or another electrically conductive material. The first pair of heater contacts may further comprise a formed shape that may comprise a tab (e.g., flange) having a flexible spring value that extends out of the heater to complete a circuit with the device body. The first pair of heater contact may be a heat sink that absorb and dissipate excessive heat produced by the resistive heating element. Alternatively, the first pair of heater contacts may be a heat shield that protects the heater chamber from excessive heat produced by the resistive heating element. The first pair of heater contacts may be press-fit to an attachment feature on the exterior wall of the first end of the cartridge. The heater may enclose a first end of the cartridge and a first end of the fluid storage compartment.

As illustrated in the exploded assembly of FIG. **7**B, a heater enclosure may comprises two or more heater contacts **33**, each comprising a flat plate which may be machined or stamped from a copper alloy or similar electrically conductive material. The flexibility of the tip is provided by the cut-away clearance feature **33***b* created below the male contact point tip **33***a* which capitalizes on the inherent spring capacity of the metal sheet or plate material. Another advantage and improvement of this type of contact is the reduced space requirement, simplified construction of a spring contact point (versus a pogo pin) and the easy of assembly. The heater may comprise a first condensation chamber. The heater may comprise more one or more additional condensation chambers in addition to the first condensation chamber. The first condensation chamber may be formed along an exterior wall of the cartridge.

In some cases, the cartridge (e.g., pod) is configured for ease of manufacturing and assembly. The cartridge may comprise an enclosure. The enclosure may be a tank. The tank may comprise an interior fluid storage compartment **32**. The interior fluid storage compartment **32** which is open at one or both ends and comprises raised rails on the side edges **45***b* and **46***b*. The cartridge may be formed from plastic, metal, composite, and/or a ceramic material. The cartridge may be rigid or flexible.

The tank may further comprise a set of first heater contact plates **33** formed from copper alloy or another electrically conductive material, having a thin cut-out **33***b* below the contact tips **33***a* (to create a flexible tab) which are affixed to the sides of the first end of the tank and straddle the open-sided end **53** of the tank. The plates may affix to pins, or posts as shown in FIG. **7**B or **5**, or may be attached by other common means such as compression beneath the enclosure **36**. A fluid wick **34** having a resistive heating element **35** wrapped around it, is placed between the first heater contact plates **33**, and attached thereto. A heater **36**, comprising raised internal edges on the internal end (not shown), a thin mixing zone (not shown), and primary condensation channel covers **45***a* that slide over the rails **45***b* on the sides of the tank on the first half of the tank, creating a primary condensation channel/chamber **45**. In addition, a small male snap feature **39***b* located at the end of the channel cover is configured fall into a female snap feature **39***a*, located mid-body on the side of the tank, creating a snap-fit assembly.

As will be further clarified below, the combination of the open-sided end **53**, the protruding tips **33***a* of the contact plates **33**, the fluid wick **34** having a resistive heating element **35**, enclosed in the open end of the fluid storage tank, under the heater **36**, with a thin mixing zone therein, creates an efficient heater system. In addition, the primary condensation channel covers **45***a* which slide over the rails

45*b* on the sides of the tank create an integrated, easily assembled, primary condensation chamber **45**, all within the heater at the first end of the cartridge **30** or pod **30***a*.

In some embodiments of the device, as illustrated in FIG. **9**, the heater may encloses at least a first end of the cartridge. The enclosed first end of the cartridge may include the heater and the interior fluid storage compartment. In some embodiments, the heater further comprises at least one first condensation chamber **45**.

FIG. **9** shows diagramed steps that mat be performed to assemble a cartomizer and/or mouthpiece. In A-B the fluid storage compartment **32***a* may be oriented such that the heater inlet **53** faces upward. The heater contacts **33** may be inserted into the fluid storage compartment. Flexible tabs **33***a* may be inserted into the heater contacts **33**. In a step D the resistive heating element **35** may be wound on to the wick **34**. In step E the wick **34** and heater **35** may be placed on the fluid storage compartment. One or more free ends of the heater may sit outside the heater contacts. The one or more free ends may be soldered in place, rested in a groove, or snapped into a fitted location. At least a fraction of the one or more free ends may be in communication with the heater contacts **33**. In a step F the heater enclosure **36** may be snapped in place. The heater enclosure **36** may be fitted on the fluid storage compartment. Step G shows the heater enclosure **36** is in place on the fluid storage compartment. In step H the fluid storage compartment can be flipped over. In step I the mouthpiece **31** can be fitted on the fluid storage compartment. Step J shows the mouthpiece **31** in place on the fluid storage compartment. In step K an end **49** can be fitted on the fluid storage compartment opposite the mouthpiece. Step L shows a fully assembled cartridge **30**. FIG. **7**B shows an exploded view of the assembled cartridge **30**.

Depending on the size of the heater and/or heater chamber, the heater may have more than one wick **34** and resistive heating element **35**.

In some embodiments, the first pair of heater contacts **33** further comprises a formed shape that comprises a tab **33***a* having a flexible spring value that extends out of the heater. In some embodiments, the cartridge **30** comprises heater contacts **33** which are inserted into the cartridge receptacle **21** of the device body **20** wherein, the flexible tabs **33***a* insert into a second pair of heater contacts **22** to complete a circuit with the device body. The first pair of heater contacts **33** may be a heat sink that absorbs and dissipates excessive heat produced by the resistive heating element **35**. The first pair of heater contacts **33** may be a heat shield that protects the heater chamber from excessive heat produced by the resistive heating element **35**. The first pair of heater contacts may be press-fit to an attachment feature on the exterior wall of the first end of the cartridge. The heater **36** may enclose a first end of the cartridge and a first end of the fluid storage compartment **32***a*. The heater may comprise a first condensation chamber **45**. The heater may comprise at least one additional condensation chamber **45**, **45'**, **45"**, etc. The first condensation chamber may be formed along an exterior wall of the cartridge.

In still other embodiments of the device, the cartridge may further comprise a mouthpiece **31**, wherein the mouthpiece comprises at least one aerosol outlet channel/secondary condensation chamber **46**; and at least one aerosol outlet **47**. The mouthpiece may be attached to a second end of the cartridge. The second end of the cartridge with the mouthpiece may be exposed when the cartridge is inserted in the device. The mouthpiece may comprise more than one second condensation chamber **46**, **46'**, **46"**, etc. The second condensation chamber is formed along an exterior wall of the cartridge.

The mouthpiece **31** may enclose the second end of the cartridge and interior fluid storage compartment. The partially assembled (e.g., mouthpiece removed) unit may be inverted and filled with a vaporizable fluid through the opposite, remaining (second) open end. Once filled, a snap-on mouthpiece **31** that also closes and seals the second end of the tank is inserted over the end. It also comprises raised internal edges (not shown), and aerosol outlet channel covers **46***a* that may slide over the rails **46***b* located on the sides of the second half of the tank, creating aerosol outlet channels/secondary condensation chambers **46**. The aerosol outlet channels/secondary condensation chambers **46** slide over the end of primary condensation chamber **45**, at a transition area **57**, to create a junction for the vapor leaving the primary chamber and proceed out through the aerosol outlets **47**, at the end of the aerosol outlet channels **46** and user-end of the mouthpiece **31**.

The cartridge may comprise a first condensation chamber and a second condensation chamber **45**, **46**. The cartridge may comprise more than one first condensation chamber and more than one second condensation chamber **45**, **46**, **45'**, **46'**, etc.

In some embodiments of the device, a first condensation chamber **45** may be formed along the outside of the cartridge fluid storage compartment **31**. In some embodiments of the device an aerosol outlet **47** exists at the end of aerosol outlet chamber **46**. In some embodiments of the device, a first and second condensation chamber **45**, **46** may be formed along the outside of one side of the cartridge fluid storage compartment **31**. In some embodiments the second condensation chamber may be an aerosol outlet chamber. In some embodiments another pair of first and/or second condensation chambers **45'**, **46'** is formed along the outside of the cartridge fluid storage compartment **31** on another side of the device. In some embodiments another aerosol outlet **47'** will also exist at the end of the second pair of condensation chambers **45'**, **46'**.

In any one of the embodiments, the first condensation chamber and the second condensation chamber may be in fluid communication as illustrated in FIG. **10**C.

In some embodiments, the mouthpiece may comprise an aerosol outlet **47** in fluid communication with the second condensation chamber **46**. The mouthpiece may comprise more than one aerosol outlet **47**, **47'** in fluid communication with more than one the second condensation chamber **46**, **46'**. The mouthpiece may enclose a second end of the cartridge and a second end of the fluid storage compartment.

In each of the embodiments described herein, the cartridge may comprise an airflow path comprising: an air inlet passage; a heater; at least a first condensation chamber; an aerosol outlet chamber, and an outlet port. In some of the embodiments described herein, the cartridge comprises an airflow path comprising: an air inlet passage; a heater; a first condensation chamber; a secondary condensation chamber; and an outlet port.

In still other embodiments described herein the cartridge may comprise an airflow path comprising at least one air inlet passage; a heater; at least one first condensation chamber; at least one secondary condensation chamber; and at least one outlet port.

As illustrated in FIGS. **10**A-**10**C, an airflow path is created when the user draws on the mouthpiece **31** to create a suction (e.g., a puff), which essentially pulls air through the channel air inlet opening **50**, through the air inlet passage **51**,

and into the heater chamber **37** through the second air passage (tank air inlet hole) **41** at the tank air inlet **52**, then into the heater inlet **53**. At this point, the pressure sensor has sensed the user's puff, and activated the circuit to the resistive heating element **35**, which in turn, begins to generate vapor from the vapor fluid (e-juice). As air enters the heater inlet **53**, it begins to mix and circulate in a narrow chamber above and around the wick **34** and between the heater contacts **33**, generating heat, and dense, concentrated vapor as it mixes in the flow path **54** created by the sealing structure obstacles **44**. FIG. **8**A shows a detailed view of the sealing structure obstacles **44**. Ultimately the vapor may be drawn, out of the heater along an air path **55** near the shoulder of the heater and into the primary condensation chamber **45** where the vapor expands and begins to cool. As the expanding vapor moves along the airflow path, it makes a transition from the primary condensation chamber **45** through a transition area **57**, creating a junction for the vapor leaving the primary chamber, and entering the second vapor chamber **46**, and proceeds out through the aerosol outlets **47**, at the end of the mouthpiece **31** to the user.

As illustrated in FIGS. **10**A-**10**C, the device may have a dual set of air inlet passages **50**-**53**, dual first condensation chambers **55**/**45**, dual second condensation chambers and aeration channels **57**/**46**, and/or dual aerosol outlet vents **47**.

Alternatively, the device may have an airflow path comprising: an air inlet passage **50**, **51**; a second air passage **41**; a heater chamber **37**; a first condensation chamber **45**; a second condensation chamber **46**; and/or an aerosol outlet **47**.

In some cases, the devise may have an airflow path comprising: more than one air inlet passage; more than one second air passage; a heater chamber; more than one first condensation chamber; more than one second condensation chamber; and more than one aerosol outlet as clearly illustrated in FIGS. **10**A-**10**C.

In any one of the embodiments described herein, the heater **36** may be in fluid communication with the internal fluid storage compartment **32***a*.

In each of the embodiments described herein, the fluid storage compartment **32** is in fluid communication with the heater chamber **37**, wherein the fluid storage compartment is capable of retaining condensed aerosol fluid, as illustrated in FIGS. **10**A, **10**C and **14**.

In some embodiments of the device, the condensed aerosol fluid may comprise a nicotine formulation. In some embodiments, the condensed aerosol fluid may comprise a humectant. In some embodiments, the humectant may comprise propylene glycol. In some embodiments, the humectant may comprise vegetable glycerin.

In some cases, the cartridge may be detachable from the device body. In some embodiments, the cartridge receptacle and the detachable cartridge may form a separable coupling. In some embodiments the separable coupling may comprise a friction assembly. As illustrated in FIGS. **11**-**14**, the device may have a press-fit (friction) assembly between the cartridge pod **30***a* and the device receptacle. Additionally, a dent/friction capture such as **43** (e.g., a detent) may be utilized to capture the pod **30***a* to the device receptacle or to hold a protective cap **38** on the pod, as further illustrated in FIG. **8**B. Alternatively or additionally the vaporizer may include a magnetic coupling **87** (e.g., within the cartridge receptacle at the proximal end of the device) to secure the cartridge by a magnetic- or magnetic assisted capture.

In other embodiments, the separable coupling may comprise a snap-fit or snap-lock assembly. In still other embodiments the separable coupling may comprise a magnetic assembly (e.g., a magnetic coupling). As mentioned above, the magnetic coupling may secure the cartridge in the cartridge receptacle.

In any one of the embodiments described herein, the cartridge components may comprise a snap-fit or snap-lock assembly, as illustrated in FIG. **5**. In any one of the embodiments, the cartridge components may be reusable, refillable, and/or recyclable. The design of these cartridge components lend themselves to the use of such recyclable plastic materials as polypropylene, for the majority of components.

In some embodiments of the device **10**, the cartridge **30** may comprise: a fluid storage compartment **32**; a heater **36** affixed to a first end with a snap-fit coupling **39***a*, **39***b*; and a mouthpiece **31** affixed to a second end with a snap-fit coupling **39***c*, **39***d* (not shown—but similar to **39***a* and **39***b*). The heater **36** may be in fluid communication with the fluid storage compartment **32**. The fluid storage compartment may be capable of retaining condensed aerosol fluid. The condensed aerosol fluid may comprise a nicotine formulation. The condensed aerosol fluid may comprise a humectant. The humectant may comprise propylene glycol and/or vegetable glycerin.

Provided herein is a device for generating an inhalable aerosol comprising: a device body **20** comprising a cartridge receptacle **21** for receiving a cartridge **30**; wherein an interior surface of the cartridge receptacle forms a first side of an air inlet passage **51** when a cartridge comprising a channel integral **40** to an exterior surface is inserted into the cartridge receptacle **21**, and wherein the channel forms a second side of the air inlet passage **51**.

Provided herein is a device for generating an inhalable aerosol comprising: a device body **20** comprising a cartridge receptacle **21** for receiving a cartridge **30**; wherein the cartridge receptacle comprises a channel integral to an interior surface and forms a first side of an air inlet passage when a cartridge is inserted into the cartridge receptacle, and wherein an exterior surface of the cartridge forms a second side of the air inlet passage **51**.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising: a fluid storage compartment **32**; a channel integral **40** to an exterior surface, wherein the channel forms a first side of an air inlet passage **51**; and wherein an internal surface of a cartridge receptacle **21** in the device forms a second side of the air inlet passage **51** when the cartridge is inserted into the cartridge receptacle.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising a fluid storage compartment **32**, wherein an exterior surface of the cartridge forms a first side of an air inlet channel **51** when inserted into a device body **10** comprising a cartridge receptacle **21**, and wherein the cartridge receptacle further comprises a channel integral to an interior surface, and wherein the channel forms a second side of the air inlet passage **51**.

In some embodiments, the cartridge further comprises a second air passage **41** in fluid communication with the channel **40**, wherein the second air passage **41** is formed through the material of the cartridge **32** from an exterior surface of the cartridge to the internal fluid storage compartment **32***a*.

In some embodiments of the device body cartridge receptacle **21** or the cartridge **30**, the integral channel **40** comprises at least one of: a groove; a trough; a depression; a dent; a furrow; a trench; a crease; and a gutter.

In some embodiments of the device body cartridge receptacle **21** or the cartridge **30**, the integral channel **40** com-

prises walls that are either recessed into the surface or protrude from the surface where it is formed.

In some embodiments of the device body cartridge receptacle **21** or the cartridge **30**, the internal side walls of the channel **40** form additional sides of the air inlet passage **51**.

Provided herein is a device for generating an inhalable aerosol comprising: a cartridge comprising; a fluid storage compartment; a heater affixed to a first end comprising; a first heater contact, a resistive heating element affixed to the first heater contact; a device body comprising; a cartridge receptacle for receiving the cartridge; a second heater contact adapted to receive the first heater contact and to complete a circuit; a power source connected to the second heater contact; a printed circuit board (PCB) connected to the power source and the second heater contact; wherein the PCB is configured to detect the absence of fluid based on the measured resistance of the resistive heating element, and turn off the device.

Referring now to FIGS. **13**, **14**, and **15**, in some embodiments, the device body further comprises at least one: second heater contact **22** (best shown in FIG. **6**C detail); a battery **23**; a printed circuit board **24**; a pressure sensor **27**; and an indicator light **26**.

In some embodiments, the printed circuit board (PCB) further comprises: a microcontroller; switches; circuitry comprising a reference resister; and an algorithm comprising logic for control parameters; wherein the microcontroller cycles the switches at fixed intervals to measure the resistance of the resistive heating element relative to the reference resistor, and applies the algorithm control parameters to control the temperature of the resistive heating element.

As illustrated in the basic block diagram of FIG. **17**A, the device utilizes a proportional-integral-derivative controller or PID control law. A PID controller calculates an "error" value as the difference between a measured process variable and a desired SetPoint. When PID control is enabled, power to the coil is monitored to determine whether or not acceptable vaporization is occurring. With a given airflow over the coil, more power will be required to hold the coil at a given temperature if the device is producing vapor (heat is removed from the coil to form vapor). If power required to keep the coil at the set temperature drops below a threshold, the device indicates that it cannot currently produce vapor. Under normal operating conditions, this indicates that there is not enough liquid in the wick for normal vaporization to occur.

In some embodiments, the micro-controller instructs the device to turn itself off when the resistance exceeds the control parameter threshold indicating that the resistive heating element is dry.

In still other embodiments, the printed circuit board further comprises logic capable of detecting the presence of condensed aerosol fluid in the fluid storage compartment and is capable of turning off power to the heating contact(s) when the condensed aerosol fluid is not detected. When the microcontroller is running the PID temperature control algorithm **70**, the difference between a set point and the coil temperature (error) is used to control power to the coil so that the coil quickly reaches the set point temperature, [between 200° C. and 400° C.]. When the over-temperature algorithm is used, power is constant until the coil reaches an over-temperature threshold, [between 200° C. and 400° C.]; (FIG. **17**A applies: set point temperature is over-temperature threshold; constant power until error reaches 0).

The essential components of the device used to control the resistive heating element coil temperature are further illustrated in the circuit diagram of FIG. **17**B. Wherein, BATT **23** is the battery; MCU **72** is the microcontroller; Q1 (**76**) and Q2 (**77**) are P-channel MOSFETs (switches); R_COIL **74** is the resistance of the coil. R_REF **75** is a fixed reference resistor used to measure R_COIL **74** through a voltage divider **73**.

The battery powers the microcontroller. The microcontroller turns on Q2 for 1 ms every 100 ms so that the voltage between R_REF and R_COIL (a voltage divider) may be measured by the MCU at V_MEAS. When Q2 is off, the control law controls Q1 with PWM (pulse width modulation) to power the coil (battery discharges through Q1 and R_COIL when Q1 is on).

In some embodiments of the device, the device body further comprises at least one: second heater contact; a power switch; a pressure sensor; and an indicator light.

In some embodiments of the device body, the second heater contact **22** may comprise: a female receptacle; or a male contact, or both, a flexible contact; or copper alloy or another electrically conductive material.

In some embodiments of the device body, the battery supplies power to the second heater contact, pressure sensor, indicator light and the printed circuit board. In some embodiments, the battery is rechargeable. In some embodiments, the indicator light **26** indicates the status of the device and/or the battery or both.

In some embodiments of the device, the first heater contact and the second heater contact complete a circuit that allows current to flow through the heating contacts when the device body and detachable cartridge are assembled, which may be controlled by an on/off switch. Alternatively, the device can be turned on an off by a puff sensor. The puff sensor may comprise a capacitive membrane. The capacitive membrane may be similar to a capacitive membrane used in a microphone.

In some embodiments of the device, there is also an auxiliary charging unit for recharging the battery **23** in the device body. As illustrated in FIGS. **16**A-**16**C, the charging unit **60**, may comprise a USB device with a plug for a power source **63** and protective cap **64**, with a cradle **61** for capturing the device body **20** (with or without the cartridge installed). The cradle may further comprise either a magnet or a magnetic contact **62** (magnetic coupling) to securely hold the device body in place during charging. As illustrated in FIG. **6**B, the device body further comprises a mating charging contact **28** and a magnet or magnetic contact **29** for the auxiliary charging unit. FIG. **16**C is an illustrative example of the device **20** being charged in a power source **65** (laptop computer or tablet).

In some cases the microcontroller on the PCB may be configured to monitor the temperature of the heater such that the vaporizable material is heated to a prescribed temperature. The prescribed temperature may be an input provided by the user. A temperature sensor may be in communication with the microcontroller to provide an input temperature to the microcontroller for temperature regulation. A temperature sensor may be a thermistor, thermocouple, thermometer, or any other temperature sensors. In some cases, the heating element may simultaneously perform as both a heater and a temperature sensor. The heating element may differ from a thermistor by having a resistance with a relatively lower dependence on temperature. The heating element may comprise a resistance temperature detector.

The resistance of the heating element may be an input to the microcontroller. In some cases, the resistance may be determined by the microcontroller based on a measurement from a circuit with a resistor with at least one known resistance, for example, a Wheatstone bridge. Alternatively,

the resistance of the heating element may be measured with a resistive voltage divider in contact with the heating element and a resistor with a known and substantially constant resistance. The measurement of the resistance of the heating element may be amplified by an amplifier. The amplifier may be a standard op amp or instrumentation amplifier. The amplified signal may be substantially free of noise. In some cases, a charge time for a voltage divider between the heating element and a capacitor may be determined to calculate the resistance of the heating element. In some cases, the microcontroller must deactivate the heating element during resistance measurements. The resistance of the heating element may be directly proportional to the temperature of the heating element such that the temperature may be directly determine from the resistance measurement. Determining the temperature directly from the heating element resistance measurement rather than from an additional temperature sensor may generate a more accurate measurement because unknown contact thermal resistance between the temperature sensor and the heating element is eliminated. Additionally, the temperature measurement may be determined directly and therefore faster and without a time lag associated with attaining equilibrium between the heating element and a temperature sensor in contact with the heating element.

Provided herein is a device for generating an inhalable aerosol comprising: a cartridge comprising a first heater contact; a device body comprising; a cartridge receptacle for receiving the cartridge; a second heater contact adapted to receive the first heater contact and to complete a circuit; a power source connected to the second heater contact; a printed circuit board (PCB) connected to the power source and the second heater contact; and a single button interface; wherein the PCB is configured with circuitry and an algorithm comprising logic for a child safety feature.

In some embodiments, the algorithm requires a code provided by the user to activate the device. In some embodiments; the code is entered by the user with the single button interface. In still further embodiments the single button interface is the also the power switch.

Provided herein is a cartridge **30** for a device **10** for generating an inhalable aerosol comprising: a fluid storage compartment **32**; a heater **36** affixed to a first end comprising: a heater chamber **37**, a first pair of heater contacts **33**, a fluid wick **34**, and a resistive heating element **35** in contact with the wick; wherein the first pair of heater contacts **33** comprise thin plates affixed about the sides of the heater chamber **37**, and wherein the fluid wick **34** and resistive heating element **35** are suspended there between.

Depending on the size of the heater or heater chamber, the heater may have more than one wick **34**, **34'** and resistive heating element **35**, **35'**.

In some embodiments, the first pair of heater contacts further comprise a formed shape that comprises a tab **33***a* having a flexible spring value that extends out of the heater **36** to complete a circuit with the device body **20**.

In some embodiments, the heater contacts **33** are configured to mate with a second pair of heater contacts **22** in a cartridge receptacle **21** of the device body **20** to complete a circuit.

In some embodiments, the first pair of heater contacts is also a heat sink that absorbs and dissipates excessive heat produced by the resistive heating element.

In some embodiments, the first pair of heater contacts is a heat shield that protects the heater chamber from excessive heat produced by the resistive heating element.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising: a heater **36** comprising; a heater chamber **37**, a pair of thin plate heater contacts **33** therein, a fluid wick **34** positioned between the heater contacts **33**, and a resistive heating element **35** in contact with the wick; wherein the heater contacts **33** each comprise a fixation site **33***c* wherein the resistive heating element **35** is tensioned there between.

As will be obvious to one skilled in the art after reviewing the assembly method illustrated in FIG. **9**, the heater contacts **33** simply snap or rest on locator pins on either side of the air inlet **53** on the first end of the cartridge interior fluid storage compartment, creating a spacious vaporization chamber containing the at least one wick **34** and at least one heating element **35**.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising a heater **36** attached to a first end of the cartridge.

In some embodiments, the heater encloses a first end of the cartridge and a first end of the fluid storage compartment **32**, **32***a*.

In some embodiments, the heater comprises a first condensation chamber **45**.

In some embodiments, the heater comprises more than one first condensation chamber **45**, **45'**.

In some embodiments, the condensation chamber is formed along an exterior wall of the cartridge **45***b*.

As noted previously, and described in FIGS. **10**A, **10**B and **10**C, the airflow path through the heater and heater chamber generates vapor within the heater circulating air path **54**, which then exits through the heater exits **55** into a first (primary) condensation chamber **45**, which is formed by components of the tank body comprising the primary condensation channel/chamber rails **45***b*, the primary condensation channel cover **45***a*, (the outer side wall of the heater enclosure).

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising a fluid storage compartment **32** and a mouthpiece **31**, wherein the mouthpiece is attached to a second end of the cartridge and further comprises at least one aerosol outlet **47**.

In some embodiments, the mouthpiece **31** encloses a second end of the cartridge **30** and a second end of the fluid storage compartment **32**, **32***a*.

Additionally, as clearly illustrated in FIG. **10**C in some embodiments the mouthpiece also contains a second condensation chamber **46** prior to the aerosol outlet **47**, which is formed by components of the tank body **32** comprising the secondary condensation channel/chamber rails **46***b*, the second condensation channel cover **46***a*, (the outer side wall of the mouthpiece). Still further, the mouthpiece may contain yet another aerosol outlet **47'** and another (second) condensation chamber **46'** prior to the aerosol outlet, on another side of the cartridge.

In other embodiments, the mouthpiece comprises more than one second condensation chamber **46**, **46'**.

In some preferred embodiments, the second condensation chamber is formed along an exterior wall of the cartridge **46***b*.

In each of the embodiments described herein, the cartridge **30** comprises an airflow path comprising: an air inlet channel and passage **40**, **41**, **42**; a heater chamber **37**; at least a first condensation chamber **45**; and an outlet port **47**. In some of the embodiments described herein, the cartridge **30** comprises an airflow path comprising: an air inlet channel

and passage **40**, **41**, **42**; a heater chamber **37**; a first condensation chamber **45**; a second condensation chamber **46**; and an outlet port **47**.

In still other embodiments described herein the cartridge **30** may comprise an airflow path comprising at least one air inlet channel and passage **40**, **41**, **42**; a heater chamber **37**; at least one first condensation chamber **45**; at least one second condensation chamber **46**; and at least one outlet port **47**.

In each of the embodiments described herein, the fluid storage compartment **32** is in fluid communication with the heater **36**, wherein the fluid storage compartment is capable of retaining condensed aerosol fluid.

In some embodiments of the device, the condensed aerosol fluid comprises a nicotine formulation. In some embodiments, the condensed aerosol fluid comprises a humectant. In some embodiments, the humectant comprises propylene glycol. In some embodiments, the humectant comprises vegetable glycerin.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** comprising: a fluid storage compartment **32**; a heater **36** affixed to a first end; and a mouthpiece **31** affixed to a second end; wherein the heater comprises a first condensation chamber **45** and the mouthpiece comprises a second condensation chamber **46**.

In some embodiments, the heater comprises more than one first condensation chamber **45**, **45'** and the mouthpiece comprises more than one second condensation chamber **46**, **46'**.

In some embodiments, the first condensation chamber and the second condensation chamber are in fluid communication. As illustrated in FIG. **10**C, the first and second condensation chambers have a common transition area **57**, **57'**, for fluid communication.

In some embodiments, the mouthpiece comprises an aerosol outlet **47** in fluid communication with the second condensation chamber **46**.

In some embodiments, the mouthpiece comprises two or more aerosol outlets **47**, **47'**.

In some embodiments, the mouthpiece comprises two or more aerosol outlets **47**, **47'** in fluid communication with the two or more second condensation chambers **46**, **46'**.

In any one of the embodiments, the cartridge meets ISO recycling standards.

In any one of the embodiments, the cartridge meets ISO recycling standards for plastic waste.

And in still other embodiments, the plastic components of the cartridge are composed of polylactic acid (PLA), wherein the PLA components are compostable and or degradable.

Provided herein is a device for generating an inhalable aerosol **10** comprising a device body **20** comprising a cartridge receptacle **21**; and a detachable cartridge **30**; wherein the cartridge receptacle and the detachable cartridge form a separable coupling, and wherein the separable coupling comprises a friction assembly, a snap-fit assembly or a magnetic assembly.

In other embodiments of the device, the cartridge is a detachable assembly. In any one of the embodiments described herein, the cartridge components may comprise a snap-lock assembly such as illustrated by snap features **39***a* and **39***b*. In any one of the embodiments, the cartridge components are recyclable.

Provided herein is a method of fabricating a device for generating an inhalable aerosol comprising: providing a device body comprising a cartridge receptacle; and providing a detachable cartridge; wherein the cartridge receptacle and the detachable cartridge form a separable coupling comprising a friction assembly, a snap-fit assembly or a magnetic assembly when the cartridge is inserted into the cartridge receptacle.

Provided herein is a method of making a device **10** for generating an inhalable aerosol comprising: providing a device body **20** with a cartridge receptacle **21** comprising one or more interior coupling surfaces **21***a*, **21***b*, **21***c* . . . ; and further providing a cartridge **30** comprising: one or more exterior coupling surfaces **36***a*, **36***b*, **36***c*, . . . , a second end and a first end; a tank **32** comprising an interior fluid storage compartment **32***a*; at least one channel **40** on at least one exterior coupling surface, wherein the at least one channel forms one side of at least one air inlet passage **51**, and wherein at least one interior wall of the cartridge receptacle forms at least one side one side of at least one air inlet passage **51** when the detachable cartridge is inserted into the cartridge receptacle.

FIG. **9** provides an illustrative example of a method of assembling such a device.

In some embodiments of the method, the cartridge **30** is assembled with a [protective] removable end cap **38** to protect the exposed heater contact tabs **33***a* protruding from the heater **36**.

Provided herein is a method of fabricating a cartridge for a device for generating an inhalable aerosol comprising: providing a fluid storage compartment; affixing a heater to a first end with a snap-fit coupling; and affixing a mouthpiece to a second end with a snap-fit coupling.

Provided herein is a cartridge **30** for a device for generating an inhalable aerosol **10** with an airflow path comprising: a channel **50** comprising a portion of an air inlet passage **51**; a second air passage **41** in fluid communication with the channel; a heater chamber **37** in fluid communication with the second air passage; a first condensation chamber **45** in fluid communication with the heater chamber; a second condensation chamber **46** in fluid communication with the first condensation chamber; and an aerosol outlet **47** in fluid communication with second condensation chamber.

Provided herein is a device **10** for generating an inhalable aerosol adapted to receive a removable cartridge **30**, wherein the cartridge comprises a fluid storage compartment [or tank] **32**; an air inlet **41**; a heater **36**, a [protective] removable end cap **38**, and a mouthpiece **31**.

Charging

In some cases, the vaporization device may comprise a power source. The power source may be configured to provide power to a control system, one or more heating elements, one or more sensors, one or more lights, one or more indicators, and/or any other system on the electronic cigarette that requires a power source. The power source may be an energy storage device. The power source may be a battery or a capacitor. In some cases, the power source may be a rechargeable battery.

The battery may be contained within a housing of the device. In some cases the battery may be removed from the housing for charging. Alternatively, the battery may remain in the housing while the battery is being charged. Two or more charge contact may be provided on an exterior surface of the device housing. The two or more charge contacts may be in electrical communication with the battery such that the battery may be charged by applying a charging source to the two or more charge contacts without removing the battery from the housing.

FIG. **18** shows a device **1800** with charge contacts **1801**. The charge contacts **1801** may be accessible from an exterior surface of a device housing **1802**. The charge contacts **1801**

may be in electrical communication with an energy storage device (e.g., battery) inside of the device housing **1802**. In some cases, the device housing may not comprise an opening through which the user may access components in the device housing. The user may not be able to remove the battery and/or other energy storage device from the housing. In order to open the device housing a user must destroy or permanently disengage the charge contacts. In some cases, the device may fail to function after a user breaks open the housing.

FIG. **19** shows an exploded view of a charging assembly **1900** in an electronic vaporization device. The housing (not shown) has been removed from the exploded view in FIG. **19**. The charge contact pins **1901** may be visible on the exterior of the housing. The charge contact pins **1901** may be in electrical communication with a power storage device of the electronic vaporization device. When the device is connected to a power source (e.g., during charging of the device) the charging pins may facilitate electrical communication between the power storage device inside of the electronic vaporization device and the power source outside of the housing of the vaporization device. The charge contact pins **1901** may be held in place by a retaining bezel **1902**. The charge contact pins **1901** may be in electrical communication with a charger flex **1903**. The charging pins may contact the charger flex such that a need for soldering of the charger pins to an electrical connection to be in electrical communication with the power source may be eliminated. The charger flex may be soldered to a printed circuit board (PCB). The charger flex may be in electrical communication with the power storage device through the PCB. The charger flex may be held in place by a bent spring retainer **1904**.

FIG. **20** shows the bent spring retainer in an initial position **2001** and a deflected position **2002**. The bent spring retainer may hold the retaining bezel in a fixed location. The bent spring retainer may deflect only in one direction when the charging assembly is enclosed in the housing of the electronic vaporization device.

FIG. **21** shows a location of the charger pins **2101** when the electronic vaporization device is fully assembled with the charging pins **2101** contact the charging flex **2102**. When the device is fully assembled at least a portion of the retaining bezel may be fitted in an indentation **2103** on the inside of the housing **2104**. In some cases, disassembling the electronic vaporization device may destroy the bezel such that the device cannot be reassembled after disassembly.

A user may place the electronic smoking device in a charging cradle. The charging cradle may be a holder with charging contact configured to mate or couple with the charging pins on the electronic smoking device to provide charge to the energy storage device in the electronic vaporization device from a power source (e.g., wall outlet, generator, and/or external power storage device). FIG. **22** shows a device **2302** in a charging cradle **2301**. The charging cable may be connected to a wall outlet, USB, or any other power source. The charging pins (not shown) on the device **2302** may be connected to charging contacts (not shown) on the charging cradle **2301**. The device may be configured such that when the device is placed in the cradle for charging a first charging pin on the device may contact a first charging contact on the charging cradle and a second charging pin on the device may contact a second charging contact on the charging cradle or the first charging pin on the device may contact a second charging contact on the charging cradle and the second charging pin on the device may contact the first charging contact on the charging cradle. The charging pins on the device and the charging contacts on the cradle may be in contact in any orientation. The charging pins on the device and the charging contacts on the cradle may be agnostic as to whether they are current inlets or outlets. Each of the charging pins on the device and the charging contacts on the cradle may be negative or positive. The charging pins on the device may be reversible.

FIG. **23** shows a circuit **2400** that may permit the charging pins on the device to be reversible. The circuit **2400** may be provided on a PCB in electrical communication with the charging pins. The circuit **2400** may comprise a metal-oxide-semiconductor field-effect transistor (MOSFET) H bridge. The MOSFET H bridge may rectify a change in voltage across the charging pins when the charging pins are reversed from a first configuration where in a first configuration the device is placed in the cradle for charging with the first charging pin on the device in contact with the first charging contact on the charging cradle to a second charging pin on the device in contact with the second charging contact on the charging cradle to a second configuration where the first charging pin on the device is in contact with the second charging contact on the charging cradle and the second charging pin on the device is in contact with the first charging contact on the charging cradle. The MOSFET H bridge may rectify the change in voltage with an efficient current path.

As shown in FIG. **23** the MOSFET H bridge may comprise two or more n-channel MOSFETs and two or more p-channel MOSFETs. The n-channel and p-channel MOSFETs may be arranged in an H bridge. Sources of p-channels MOSFETs (Q1 and Q3) may be in electrical communication. Similarly, sources of n-channel FETs (Q2 and Q4) may be in electrical communication. Drains of pairs of n and p MOSFETs (Q1 with Q2 and Q3 with Q4) may be in electrical communication. TA common drain from one n and p pair may be in electrical communication with one or more gates of the other n and p pair and/or vice versa. Charge contacts (CH1 and CH2) may be in electrical communication to common drains separately. A common source of the n MOSFETs may be in electrical communication to PCB ground (GND). The common source of the p MOSFETs may be in electrical communication with the PCB's charge controller input voltage (CH+). When CH1 voltage is greater than CH2 voltage by the MOSFET gate threshold voltages, Q1 and Q4 may be "on," connecting CH1 to CH+ and CH2 to GND. When CH2 voltage is greater than CH1 voltage by the FET gate threshold voltages, Q2 and Q3 may be "on," connecting CH1 to GND and CH2 to CH+. For example, whether there is 9V or −9V across CH1 to CH2, CH+ will be 9V above GND. Alternatively, a diode bridge could be used, however the MOSFET bridge may be more efficient compared to the diode bridge.

In some cases the charging cradle may be configured to be a smart charger. The smart charger may put the battery of the device in series with a USB input to charge the device at a higher current compared to a typical charging current. In some cases, the device may charge at a rate up to about 2 amps (A), 4 A, 5 A, 6 A, 7 A, 10 A, or 15 A. In some cases, the smart charger may comprise a battery, power from the battery may be used to charge the device battery. When the battery in the smart charger has a charge below a predetermined threshold charge, the smart charger may simultaneously charge the battery in the smart charger and the battery in the device.

Cartridge/Vaporizer Attachment

Any of the cartridges described herein may be adapted for securely coupling with an electronic inhalable aerosol device ("vaporizer") as discussed above. In particular

described herein are cartridge designs that address the unrecognized problem of maintaining adequate electrical contact between a mouthpiece-containing cartridge and a rectangular vaporizer coupling region, particularly when the mouthpiece is held in a user's mouth.

Any of the cartridges described herein may be particularly well adapted for securing to a vaporizer by including a base region that mates with the rectangular coupling region of the vaporizer, where the base unit fits into a rectangular opening that is between 13-14 mm deep, 4.5-5.5 mm wide, and 13-14 mm long. The base having generally includes a bottom surface having a first electrical contact and a second electrical contact. In particular, any of the cartridges described herein may include a first locking gap on a first lateral surface of the base, and a second locking gap on a second lateral surface of the base that is opposite first lateral surface.

For example FIGS. **24**A and **24**B illustrate another variation of a cartridge having a base region **2401** with at least one locking gap **2404** on the first minor lateral wall **2407**. A second locking gap (not shown) may be present on the opposite minor lateral wall. One or both major lateral walls **2418** may include a detent **2421**. Any of these cartridges may also include a mouthpiece **2409**, which may be at an end that is opposite of the bottom **2422**, on which a pair of electrodes **2411** are positioned. FIGS. **25**A and **25**B show front and side views, respectively, of this example. The mouthpiece **2431** may have a distal edge **2471** that fits over the (transparent or translucent) elongate body (the elongate and flattened storage compartment configured to hold a liquid vaporizable material) of the cartridge and overhands it slightly, forming a lip or distal edge **2471** that extends only partially between the distal end and the proximal end of the storage compartment. A cannula **2475** is visible in the figure.

In FIGS. **24**A-**25**B the locking gaps **2404**, **2404'** on either side are shown as channels in the side (lateral) walls. They may extend across the entire side wall, parallel to the bottom as shown, or they may extend only partially through and may preferably be centered relative to the width of the wall. In other variations the locking gap may be a divot, pit, opening, or hole (though not into the internal volume holding the vaporizable material).

In general, the inventors have found that the vertical position of the locking gap may be important in maintaining the stability of the cartridge in the vaporizer, particularly in cartridges having a rectangular base region that is longer than 10 mm. Optimally, the locking gap may be between about 1 and 5 mm from the bottom of the base region, and more specifically, between about 3 and 4 mm (e.g., approximately 3.3 mm), as shown in FIG. **26**A which indicates exemplary dimensions for the section through FIG. **26**B.

The cartridges shown in FIGS. **24**A-**24**B also include a detent **2421** that is positioned between about 7 and 11 mm up from the bottom of the cartridge. The detent may help hold the cartridge base in the vaporizer, and may cooperate with the locking gap, but is optional (and shown in dashed lines in FIGS. **2**A-**25**B.

In FIGS. **24**A-**25**B the cartridge base is also transparent, and shows an internal air channel (cannula **2505**).

FIGS. **27**A-**27**B show another example of a vaporizer including a battery and control circuitry. FIGS. **27**A and **27**B also illustrate the mating region **2704** (cartridge receptacle). In this example, the mating region includes two detents **2706** that may mate with the locking gaps on the cartridge when it is inserted into the vaporizer. Exemplary dimensions for the mating region are shown. In this example the locking detents (which complement the locking gaps on the cartridge) are indentations that project into the mating region. These locking determent may be a ridge, pin, or other projection (including spring-loaded members).

FIGS. **28**A-**28**D show an example of a vaporizer **2803** into which a cartridge **2801** has been securely loaded. In FIG. **28**A the cartridge has been snapped into position so that the locking gaps of the cartridge engage with the locking detents in the vaporizer. FIG. **28**B is side view and FIG. **28**C show a sectional view; an enlarged portion of the sectional view is shown in FIG. **28**D, showing the base of the cartridge seated in the mating region of the vaporizer. With the cartridge secured as shown, good electrical contact **2805** may be maintained. As seen in FIG. **28**A (and as was previously seen in FIGS. **5**-**6**D and **11**-**15**) the vaporizer **2803** includes an elongate, flattened and opaque body having a distal end and a proximal end and a front side **2815**, a back side and opposite lateral sides **2817** extending between the distal and proximal ends. This shape may prevent the elongate, flattened and opaque body is prevented from rolling when placed on a flat surface because the diameter of the front and back sides are larger than the diameter of the opposite lateral sides. The vaporizer also includes a cartridge receptacle **2704** (clearly visible in the cross-section of FIG. **27**B) formed at the proximal end of the elongate, flattened and opaque body, wherein the cartridge receptacle has a proximal-facing opening into the proximal end of the elongate, flattened and opaque body. The cartridge receptacle includes a proximal edge **2722** around the proximal-facing opening, and a notch **2724** or cut-out region in the proximal edge of the cartridge receptacle. The notch may be in the front and/or back side of the elongate, flattened and opaque body extending towards the distal end of the elongate, flattened and opaque body so that a portion of the storage compartment and the cannula within the storage compartment are visible through the notch when the cartridge is housed within the cartridge receptacle, as shown in FIG. **258**A.

In the sectional view of FIG. **28**D, the cartridge is held securely within the cartridge receptacle by a pair of detents **2706** on either side (in this case, on two of the lateral sides) of the cartridge receptacle that mate with and engage a mating region (locking gaps **2736**) on opposite sides of the cartridge. The detents project into the cartridge receptacle and each engage a mating region (locking gap) on or in the lateral sides of the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle.

When secured by this friction coupling as shown, the electrical contacts **2844** in or on the distal surface within the cartridge receptacle connect to electrical contacts **2411** (electrodes) on the cartridge. As mentioned above, the electrical contacts **2844** (see, e.g., FIG. **24**B and for the vaporizer in the cartridge receptacle may be pogo pins.

A mechanical coupling or connection between the cartridge **2801** and the vaporizer **2803** is visible in the enlarged view of FIG. **28**D. In this example, the outer surface of the elongate and flattened storage compartment **2855** (which is not covered at the distal end by the mouthpiece) engages snugly within the walls of the cartridge receptacle **2851**. The Although the cartridges shown in FIGS. **24**A-**28**D are similar, and include a proximal mouthpiece and distal base that are nearly equivalent in size, with the reservoir for the vaporizable material between them and the wick, resistive heater, heating chamber and electrodes at the distal most end (near the bottom of the base), many other cartridge configurations are possible while still securely seating into a vaporizer having the same vaporizer mating region shown in FIGS. **28**A-**28**B. For example, FIGS. **29**A-**29**D illustrate

alternative variations of cartridges having similar electrode. In FIG. **29**A the base region includes two projecting feet that include locking gaps (mating regions on the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle), and the electrodes on the base (not shown) connect via electrical traces (e.g. wires, etc.) to a heating element, wick and the reservoir nearer to the distal end (not visible).

In FIG. **29**B the base extends further than 11 mm (e.g., 20-30 mm) and may house the reservoir (fluid storage compartment). Similarly in FIG. **29**C the base region is the same as in FIG. **29**B, but the more proximal portion is enlarged. In FIG. **29**D the fluid non-base portion of the cartridge (more proximal than the base region) may have a different dimension. All of the variations shown in FIGS. **29**A-**29**D, as in the variations shown in FIG. **24**A-**25**B, may mate with the same vaporizer, and because of the dimensions of the base region, may be securely held and maintain electrical contact, even when a user is holding the device in their mouth.

Similarly, FIGS. **29**E-**29**H illustrate variations of cartridges that may house the fluid storage compartment. Each of FIGS. **29**E-**29**H, as in FIGS. **29**A-**29**D, show an elongate and flattened storage compartment and an opaque mouthpiece at the proximal end of the storage compartment. In FIGS. **29**F and **29**G, the mouthpiece includes a cut-out notch as illustrated and described above for FIGS. **5**, **7**, **9**, **24**A-**24**B, and **28**A. Any of the examples shown in FIGS. **29**A-**29**H may include a mating region on the storage compartment of the cartridge to hold the cartridge within the cartridge receptacle with the mouthpiece outside of the cartridge receptacle.

For example, FIG. **30** shows one example of a cartridge including a reservoir that may be filled as described herein. FIGS. **1**A-**1**G show a schematic illustration of another example of cartridge. In general a cartridge may include a reservoir into which fluid may be filled, a tank **3001** (housing the reservoir), an elastomeric cap, and a porous wick at one end of the tank, which passes from within the tank to an external surface. The porous wick may be any appropriate material, including woven, braided, fibrous, and knitted materials. The wick may be coupled with or integral with a heating element. For example, a wire for resistive heating may be wrapped around an external portion of the wick, forming a wick/coil assembly **3005** as shown in FIG. **30**. The wick may be any appropriate material, including metals, polymers, natural fibers, synthetic fibers, or combinations of these. The wick is porous and provides a capillary pathway for fluid within the tank through and into the wick; the capillary pathway is generally large enough to permit wicking of sufficient material to replace vaporized liquid transferred from the tank by capillary action (wicking) during use of the electronic cigarette, but may be small enough to prevent leakage of the vaporizable fluid material out of the cartridge during normal operation, including when applying pressure (e.g., squeezing) the cartridge. The external portion of the wick may include a wick housing **3005**. The wick housing and/or wick may be treated to prevent leakage. For example, the wick and/or wick housing may be coated after filling to prevent leakage and/or evaporation through the wick until activated by connecting to an electronic cigarette and/or applying current through the electrical contacts **3007** (e.g., operation in an electronic cigarette), or otherwise using the cartridge. Any appropriate coating may be used, including a heat-vaporizable coating (e.g., a wax or other material), a frangible material, or the like.

The cartridge may also include an air path through the tank (shown as a cannula **3009** in FIG. **30**), which may at least partially partition the volume of the tank. The tank may include an elastomeric potion, such as all or a portion of the side, bottom, top, etc. In FIG. **30**, the tank is covered by an elastomeric cap **3011** (elastomeric tank cap). The elastomeric portion (e.g., cap) may, in some variations, be on an opposite side from the wick.

In the variation shown in FIG. **30**, the cartridge including the tank also include a cover (cap **3015**) and is configured to be used as a mouthpiece, so includes a mouthpiece portion **3017** that is separated from the tank **3001** by one or more absorbent pads **3019**.

In general, the methods described herein may include filling the tank (e.g. of a cartridge) that includes a wick at one end. The method may generally include positioning the empty and fully assembled tank (e.g. cartridge) so that it may be filled by a single needle that is inserted from the bottom or side (but not the top) of the empty tank. For example, the tank may be held on its side or upside down.

EXAMPLES

Any of the cartridges described in the figures and description above may include an elongate and flattened storage compartment for holding a vaporizable material and a mouthpiece at the proximal end of cartridge. In particular, FIGS. **5**-**7**B, **8**B, **9**, **11**-**15**, and **16**C show examples of a cartridge for use with a vaporizer device that includes an elongate and flattened storage compartment (see, element **32** in FIG. **7**B and element **32***a* in FIG. **9**) configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment, further wherein the storage compartment comprises a distal end and a proximal end, and a first side extending between the distal end and the proximal end. In each of these examples the cartridge also includes an opaque mouthpiece (e.g., **31** in FIGS. **7**B and **8**B) that is secured over the proximal end of the storage compartment, the opaque mouthpiece having a front side adjacent to the first side of the storage compartment, wherein a distal end of the opaque mouthpiece terminates in a distal edge that extends only partially between the distal end and the proximal end of the storage compartment. The mouthpiece includes an opening **72**, **72'** through the opaque mouthpiece at a proximal end of the opaque mouthpiece. The mouthpiece also includes a notch (in FIGS. **5**, **7**A, **7**B, **8**, **9** and **11**-**13**, the notch is a triangular-shaped cut-out region **88** in the front side of the mouthpiece extending from the distal edge of the opaque mouthpiece toward the proximal end of the mouthpiece, wherein the notch exposes a region of the storage compartment beneath the mouthpiece. The notch (cut-out region) in either the mouthpiece or he vaporizer body may be any appropriate shape, including rectangular, hexagonal, oval, semi-circular, pentagonal, etc. (or any combination of these). Any of the cartridges described herein may also include a heater at the distal end of the storage compartment, wherein the heater comprises a heating chamber, a wick **34** within the heating chamber, and a resistive heating element **35** in thermal contact with the wick. Any of these cartridges may also include a channel **46** or cannula within the storage compartment extending from the heater to the proximal end of the storage compartment, wherein the liquid vaporizable material is visible through the notch, further wherein the cannula or channel forms a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be

inhaled, as shown in FIGS. **7**CB and **8**B. In some variations, the channel may extend through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula when the storage compartment is filled with liquid vaporizable material. The cannula may be visible through the notch. The cannula may form a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled.

The cartridges shown in FIGS. **7**A-**9** may also include a friction coupling between the cartridge and the vaporizer. For example, the cartridge may include a pair of locking gaps on lateral sides of the cartridge that are configured to engage with a pair of locking detents on the vaporizer device to secure the cartridge in the vaporizer device.

As discussed above, these features are also apparent in FIGS. **24**A-**26**B, although the notch **2481** in this example may be shaped differently (e.g., shown as half of a flattened hexagon, compared to the half-diamond shape of FIGS. **8**B and **9**. For example, in FIGS. **24**A-**24**B and **30**, the cartridge **2000** for use with a vaporizer device includes the elongate and flattened storage compartment **2490** configured to hold a liquid vaporizable material, wherein the liquid vaporizable material is visible through the storage compartment. The storage compartment includes a distal end and a proximal end, and a first side **2492** extending between the distal end and the proximal end. The cartridge also includes an opaque mouthpiece **2409** that is secured over the proximal end of the storage compartment, the opaque mouthpiece having a front side **2494** adjacent to the first side of the storage compartment, wherein a distal end of the opaque mouthpiece terminates in a distal edge **2471** that extends only partially between the distal end and the proximal end of the storage compartment. The mouthpiece also includes an opening **2495** through the opaque mouthpiece at a proximal end of the opaque mouthpiece, and a notch **2481** in the front side of the mouthpiece extending from the distal edge of the opaque mouthpiece toward the proximal end of the mouthpiece, wherein the notch exposes a region of the storage compartment beneath the mouthpiece. The cartridge also includes a heater **2485** at the distal end of the storage compartment, wherein the heater comprises a heating chamber **2486**, a wick (not visible in FIG. **24**A-**24**B) within the heating chamber, and a resistive heating element (not visible in FIG. **24**A-**24**B) in thermal contact with the wick. The cartridge also includes a cannula **2475**, **3009** within the storage compartment extending through the liquid vaporizable material from the heater to the proximal end of the storage compartment so that the liquid vaporizable material surrounds the cannula when the storage compartment is filled with liquid vaporizable material. The cannula is visible through the notch **2481** (e.g., when the cartridge is inserted into the vaporizer fully, as shown in FIG. **33**A), further wherein the cannula forms a fluid connection between the heating chamber and the opening through the opaque mouthpiece from which vaporized liquid vaporizable material may be inhaled.

As mentioned above, the opaque mouthpiece may be attached over the proximal end of the elongate storage compartment in any appropriate manner, including an adhesive and/or a snap-fit over the proximal end of the storage compartment.

FIGS. **31**A-**31**L show alternative examples the mouthpiece cut-out regions (notches) that may be used. In all of these examples, the opaque mouthpiece is fixed (e.g., by adhesive, snap-fit, etc.) over the transparent or translucent elongate and flattened storage compartment **3103**, similar to the examples described above (e.g., in FIG. **9**). The heater region **3107** at the distal end includes a wick and coil (as shown in FIGS. **8**D and **30**), and a cannula **3109** is visible through the storage compartment and connects the heater forming the vapor to one or more openings on the mouthpiece. Each of the variations shown in FIGS. **31**A-**31**L has a different notch or cut-out region **3111**. The notch extends from the distal edge of the mouthpiece up towards the proximal end of the mouthpiece and exposes a window through the transparent/translucent storage compartment even when the cartridge is inserted into a vaporizer up to the distal edge formed by the mouthpiece. Thus, in general, this notch, cut-out or window extends up into the lateral side of the mouthpiece, e.g., on the front and/or back sides of the opaque mouthpiece between the distal and proximal ends of the cartridge. For example, the notch cuts up into the opaque mouthpiece from the lateral edges of the mouthpiece that extend along the minor sides (e.g., see the side **2509** of the mouthpiece **2431** in FIG. **25**B, and it's opposite side, not visible in FIG. **25**B), and at the lateral sides of the front and back distal edge that are at the same height as the distal edge of the mouthpiece on the minor sides of the mouthpiece. The minor sides are also referred to as the lateral sides. Note that the lateral sides are shown as having a diameter that is less than the diameter of the major (front, back) sides of the cartridge in many of these examples, which are primarily rectangular or approximately rectangular. As mentioned above, other non-rectangular, but still flattened and elongate cartridge profiles (e.g., storage compartment profiles) may be used, including hexagonal (e.g., having two pairs of minor sides with diameters that are slightly less than or equal to the major sides), oval (where the minor sides are rounded, rather than flat, etc.

The notch (cut-out region) forming the window in the cartridge may mate with complementary notch on the vaporizer, as shown in FIGS. **32**-**34**L, below. In this case, the cartridge notch forms half the window, while the vaporizer notch (through the cartridge receptacle) forms the other half of the notch. The distal-most edge of the mouthpiece around the storage compartment sits flush against the vaporizer (e.g., against the upper proximal rim of the cartridge receptacle).

For example, FIG. **31**A shows a notch **3111** that is a semicircle or semi-oval shape. FIG. **31**B is a semi-octagonal shape; FIG. **31**C shows two triangular (or semi-diamond) adjacent notches. FIG. **31**D shows a semi-crescent notch. FIG. **31**E shows a semi-star notch; FIG. **31**F shows a semi-lip notch; FIG. **31**G shows a semi-clover notch. FIG. **31**H shows a Gaussian notch. FIG. **31**I shows a semi-square (or rectangular) notch. FIG. **31**J is a pair of adjacent semi-circular or semi-oval notches. FIG. **31**K shows a semi-plus-shaped notch. FIG. **31**L is an alternative semi-star-shaped notch.

FIG. **32** shows a cartridge **3203** such as the one shown in FIGS. **24**A-**25**B coupled in the cartridge receptacle at the proximal end of an elongate flattened body **3205** of a vaporizer. In this example, the hemi-hexagonal notch in the front (and back) of the mouthpiece of the cartridge forms a hexagonal window with the complementary notch in the cartridge receptacle. The cannula is visible within the storage compartment and may provide a convenience reference, contrast, and scale for any vaporizing fluid within the storage compartment. The internal cannula may also provide a baffle to prevent or reduce bubbles forming within the vaporizable material.

Although the examples shown in FIGS. **32-34**L all show a notch cut in the distal edge of the cartridge receptacle, this second notch may be optional. Also, although the notches are shown to be mirrors of each other, the first notch (in the cartridge) may be different from the second notch.

When a feature or element is herein referred to as being "on" another feature or element, it can be directly on the other feature or element or intervening features and/or elements may also be present. In contrast, when a feature or element is referred to as being "directly on" another feature or element, there are no intervening features or elements present. It will also be understood that, when a feature or element is referred to as being "connected", "attached" or "coupled" to another feature or element, it can be directly connected, attached or coupled to the other feature or element or intervening features or elements may be present. In contrast, when a feature or element is referred to as being "directly connected", "directly attached" or "directly coupled" to another feature or element, there are no intervening features or elements present. Although described or shown with respect to one embodiment, the features and elements so described or shown can apply to other embodiments. It will also be appreciated by those of skill in the art that references to a structure or feature that is disposed "adjacent" another feature may have portions that overlap or underlie the adjacent feature.

Terminology used herein is for the purpose of describing particular embodiments only and is not intended to be limiting of the invention. For example, as used herein, the singular forms "a", "an" and "the" are intended to include the plural forms as well, unless the context clearly indicates otherwise. It will be further understood that the terms "comprises" and/or "comprising," when used in this specification, specify the presence of stated features, steps, operations, elements, and/or components, but do not preclude the presence or addition of one or more other features, steps, operations, elements, components, and/or groups thereof. As used herein, the term "and/or" includes any and all combinations of one or more of the associated listed items and may be abbreviated as "/".

Spatially relative terms, such as "under", "below", "lower", "over", "upper" and the like, may be used herein for ease of description to describe one element or feature's relationship to another element(s) or feature(s) as illustrated in the figures. It will be understood that the spatially relative terms are intended to encompass different orientations of the device in use or operation in addition to the orientation depicted in the figures. For example, if a device in the figures is inverted, elements described as "under" or "beneath" other elements or features would then be oriented "over" the other elements or features. Thus, the exemplary term "under" can encompass both an orientation of over and under. The device may be otherwise oriented (rotated 90 degrees or at other orientations) and the spatially relative descriptors used herein interpreted accordingly. Similarly, the terms "upwardly", "downwardly", "vertical", "horizontal" and the like are used herein for the purpose of explanation only unless specifically indicated otherwise.

Although the terms "first" and "second" may be used herein to describe various features/elements (including steps), these features/elements should not be limited by these terms, unless the context indicates otherwise. These terms may be used to distinguish one feature/element from another feature/element. Thus, a first feature/element discussed below could be termed a second feature/element, and similarly, a second feature/element discussed below could be termed a first feature/element without departing from the teachings of the present invention.

Throughout this specification and the claims which follow, unless the context requires otherwise, the word "comprise", and variations such as "comprises" and "comprising" means various components can be co-jointly employed in the methods and articles (e.g., compositions and apparatuses including device and methods). For example, the term "comprising" will be understood to imply the inclusion of any stated elements or steps but not the exclusion of any other elements or steps.

As used herein in the specification and claims, including as used in the examples and unless otherwise expressly specified, all numbers may be read as if prefaced by the word "about" or "approximately," even if the term does not expressly appear. The phrase "about" or "approximately" may be used when describing magnitude and/or position to indicate that the value and/or position described is within a reasonable expected range of values and/or positions. For example, a numeric value may have a value that is +/−0.1% of the stated value (or range of values), +/−1% of the stated value (or range of values), +/−2% of the stated value (or range of values), +/−5% of the stated value (or range of values), +/−10% of the stated value (or range of values), etc. Any numerical values given herein should also be understood to include about or approximately that value, unless the context indicates otherwise. For example, if the value "10" is disclosed, then "about 10" is also disclosed. Any numerical range recited herein is intended to include all sub-ranges subsumed therein. It is also understood that when a value is disclosed that "less than or equal to" the value, "greater than or equal to the value" and possible ranges between values are also disclosed, as appropriately understood by the skilled artisan. For example, if the value "X" is disclosed the "less than or equal to X" as well as "greater than or equal to X" (e.g., where X is a numerical value) is also disclosed. It is also understood that the throughout the application, data is provided in a number of different formats, and that this data, represents endpoints and starting points, and ranges for any combination of the data points. For example, if a particular data point "10" and a particular data point "15" are disclosed, it is understood that greater than, greater than or equal to, less than, less than or equal to, and equal to 10 and 15 are considered disclosed as well as between 10 and 15. It is also understood that each unit between two particular units are also disclosed. For example, if 10 and 15 are disclosed, then 11, 12, 13, and 14 are also disclosed.

Although various illustrative embodiments are described above, any of a number of changes may be made to various embodiments without departing from the scope of the invention as described by the claims. For example, the order in which various described method steps are performed may often be changed in alternative embodiments, and in other alternative embodiments one or more method steps may be skipped altogether. Optional features of various device and system embodiments may be included in some embodiments and not in others. Therefore, the foregoing description is provided primarily for exemplary purposes and should not be interpreted to limit the scope of the invention as it is set forth in the claims.

The examples and illustrations included herein show, by way of illustration and not of limitation, specific embodiments in which the subject matter may be practiced. As mentioned, other embodiments may be utilized and derived there from, such that structural and logical substitutions and changes may be made without departing from the scope of

this disclosure. Such embodiments of the inventive subject matter may be referred to herein individually or collectively by the term "invention" merely for convenience and without intending to voluntarily limit the scope of this application to any single invention or inventive concept, if more than one is, in fact, disclosed. Thus, although specific embodiments have been illustrated and described herein, any arrangement calculated to achieve the same purpose may be substituted for the specific embodiments shown. This disclosure is intended to cover any and all adaptations or variations of various embodiments. Combinations of the above embodiments, and other embodiments not specifically described herein, will be apparent to those of skill in the art upon reviewing the above description.

What is claimed is:

1. A cartridge for generating an aerosol, the cartridge comprising:

a body including a storage compartment configured to hold a vaporizable material, the body having a first end and a second end opposite the first end, the body comprising a surface between the first end and the second end;

a heating element configured to generate the aerosol, the generating of the aerosol comprising heating the vaporizable material; and

a mouthpiece secured over the first end, the mouthpiece having a notch extending away from the second end towards the first end, the mouthpiece covering a first portion of the surface,

the mouthpiece not covering a second portion of the surface, the second portion of the surface configured for insertion into a cartridge receptacle of a vaporizer device,

the mouthpiece not covering a third portion of the surface, the third portion of the surface comprising an area between the notch and the second end, the third portion of the surface being visible when the second portion of the surface is inserted into the cartridge receptacle.

2. The cartridge of claim **1**, wherein the mouthpiece is opaque, wherein the surface is transparent, and wherein the vaporizable material is visible through the surface.

3. The cartridge of claim **1**, wherein the cartridge receptacle has a receptacle notch extending away from an opening of the cartridge receptacle at a proximal end of the vaporizer device, the receptacle notch extending towards a distal end of the vaporizer device opposite the proximal end, and wherein the third portion of the surface comprises an area between the receptacle notch and the first end of the storage compartment, when the second portion of the surface is inserted into the cartridge receptacle.

4. The cartridge of claim **1**, wherein the heating element is disposed proximate to the second end of the body.

5. The cartridge of claim **1**, further comprising a wicking material configured to contact the vaporizable material, wherein the heating element is disposed proximate to the wicking material.

6. The cartridge of claim **5**, wherein the wicking material comprises at least one of: a silica material, a cotton material, a ceramic material, a hemp material, and a stainless steel material.

7. The cartridge of claim **1**, wherein the second portion of the surface comprises a locking gap integral to the storage compartment, and wherein the locking gap is configured to mate with a locking detent within the cartridge receptacle, when the second portion of the surface is inserted into the cartridge receptacle.

8. The cartridge of claim **1**, wherein the heating element comprises a resistive heating coil, and wherein the cartridge further comprises:

a first heater contact electrically coupled to the resistive heating coil, the first heater contact configured to mate with either of a first receptacle contact within the cartridge receptacle or a second receptacle contact within the cartridge receptacle, when the second portion of the surface is inserted into the cartridge receptacle; and

a second heater contact electrically coupled to the resistive heating coil, the second heater contact configured to mate with either of the second receptacle contact or the first receptacle contact, when the second portion of the surface is inserted into the cartridge receptacle.

9. The cartridge of claim **8**, wherein the first heater contact and the second heater contact are configured to complete, when the second portion of the surface is inserted into the cartridge receptacle, an electrical circuit comprising a power source within the vaporizer device, the resistive heating coil, the first receptacle contact, and the second receptacle contact.

10. The cartridge of claim **1**, wherein the body is non-cylindrical.

11. The cartridge of claim **10**, wherein the body comprises four substantially rectangular surfaces between the first end of the body and the second end of the body, the four substantially rectangular surfaces exterior to the body.

12. An apparatus for generating an aerosol, the apparatus comprising:

a vaporizer device comprising a cartridge receptacle; and

a cartridge comprising:

a body including a storage compartment configured to hold a vaporizable material, the body having a first end and a second end opposite the first end, the body comprising a surface between the first end and the second end;

a heating element configured to generate the aerosol, the generating of the aerosol comprising heating the vaporizable material; and

a mouthpiece secured over the first end, the mouthpiece covering a first portion of the surface, the mouthpiece not covering a second portion of the surface, the second portion of the surface configured for insertion into the cartridge receptacle, the mouthpiece not covering a third portion of the surface, the third portion of the surface being visible when the second portion of the surface is inserted into the cartridge receptacle.

13. The apparatus of claim **12**, wherein the mouthpiece is opaque, wherein the surface is transparent, and wherein the vaporizable material is visible through the surface.

14. The apparatus of claim **12**, wherein the mouthpiece comprises a notch extending away from the second end of the body towards the first end of the body, and wherein the third portion of the surface comprises an area between the notch and the second end of the storage compartment.

15. The apparatus of claim **12**, wherein the cartridge receptacle has a notch extending away from an opening of the cartridge receptacle at a proximal end of the vaporizer device, the notch extending towards a distal end of the vaporizer device opposite the proximal end, and wherein the third portion of the surface comprises an area between the notch and the first end of the body, when the second portion of the surface is inserted into the cartridge receptacle.

16. The apparatus of claim **12**, wherein the cartridge further comprises a wicking material configured to contact

the vaporizable material, wherein the heating element is disposed proximate to the wicking material, and wherein the wicking material comprises at least one of: a silica material, a cotton material, a ceramic material, a hemp material, and a stainless steel material.

17. The apparatus of claim **12**, wherein the second portion of the surface comprises a locking gap integral to the storage compartment, and wherein the locking gap is configured to mate with a locking detent within the cartridge receptacle, when the second portion of the surface is inserted into the cartridge receptacle.

18. The apparatus of claim **12**, wherein the heating element comprises a resistive heating coil, and wherein the cartridge further comprises:

a first heater contact electrically coupled to the resistive heating coil, the first heater contact configured to mate with either of a first receptacle contact within the cartridge receptacle or a second receptacle contact within the cartridge receptacle, when the second portion of the surface is inserted into the cartridge receptacle; and

a second heater contact electrically coupled to the resistive heating coil, the second heater contact configured to mate with either of the second receptacle contact or the first receptacle contact, when the second portion of the surface is inserted into the cartridge receptacle, wherein the first heater contact and the second heater contact are configured to complete, when the second portion of the surface is inserted into the cartridge receptacle, an electrical circuit comprising a power source within the vaporizer device, the resistive heating coil, the first receptacle contact, and the second receptacle contact.

19. The apparatus of claim **12**, wherein the cartridge receptacle is non-cylindrical, wherein the body is non-cylindrical, and wherein the body comprises four substantially rectangular surfaces between the first end of the body and the second end of the body.

20. The cartridge of claim **1**, further comprising the vaporizable material within the storage compartment, wherein the vaporizable material comprises a nicotine formulation.

21. The apparatus of claim **12**, wherein the cartridge further comprises the vaporizable material within the storage compartment, and wherein the vaporizable material comprises a nicotine formulation.

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